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ABSTRACT

A quasi-experimental non-equivalent control group design was used to investigate the effects of full-spectrum light, prescribed color and light/color combinations, ultra-violet light, and electromagnetic radiation in an elementary school environment. Four schools in the Wetaskiwin School District, Alberta, were involved in the study; three served as experimental groups and one as a control group. Independent variables were exposure to full-spectrum light or prescribed cool colors for teachers and prescribed warm colors for students or a combination of light and color treatments, ultraviolet light for a sample of grade five students, and elimination of electromagnetic radiation for a sample of grade three students. Dependent variables were primarily student academic, physiological, and affective outcomes and also included blood pressure as a teacher physiological measure. A pre-experimental static-group comparison design was used in the investigation of mood and noise. Overall results support a call for additional field-based and laboratory research into the effects of color, light, and color/light combinations. Findings regarding the beneficial effects of ultraviolet light and reduction of electromagnetic radiation in the school environment support strong recommendations for further study of these effects. An extensive literature review of research findings on light and color is included in the report, which also contains 58 tables, 12 figures, and a bibliography. Appendixes include an analysis of pre-adolescent mood variation, a report of an investigation of electromagnetic radiation and student off-task behavior, and an illuminance survey of schools of the Wetaskiwin School District. (Author/RH)

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Colour and Light Effects On Students' Achievement, Behaviour, and Physiology

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COLOR AND LIGHT EFFECTS
ON STUDENTS'
ACHIEVEMENT, BEHAVIOR AND PHYSIOLOGY

- by -

Professor H. Wohlfarth
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Alberta Education funded this study; and,

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ABSTRACT

A quasi-experimental non-equivalent control group design was used to investigate the effects of full-spectrum light, prescribed color and light/color combinations, ultraviolet light and electromagnetic radiation in an elementary school environment. Four schools in the Wetaskiwin School District were involved in this study; three served as experimental groups and one as the control group. The independent variables were exposure to full-spectrum light or prescribed cool colors for teachers and prescribed warm colors for students or a combination of light and color treatments, ultraviolet light for a sample of grade five students and elimination of electromagnetic radiation for a sample of grade three students. Dependent variables were primarily student academic, physiological and affective outcomes and also included blood pressure as a teacher physiological measure. A pre-experimental static-group comparison design was used in the investigation of mood and noise.

No consistent significant cause-effect relationship was found between the independent variables and students' ability or academic levels, attitudes toward school subjects, misbehaviors warranting disciplinary action, absences due to illness, refractive eye problems or blood pressure. Sporadic significant cause-effect relationships for student blood pressure were obtained and color affected consistent, though non-significant increases in a.m. to p.m. blood pressure suggesting the stimulating yellows in the classrooms may have some short term effect on students. No relationship was evident for teacher's blood pressure.

Significant relationships were obtained between the independent variables of color/light and student pre adolescent mood variations and noise levels. In addition, a causal effect was demonstrated for supplemental levels of ultraviolet light and reduced incidence of dental caries and absences due to illness of grade five students. Furthermore, off task behaviors of heterogeneously grouped grade three students were significantly reduced when electromagnetic radiation associated with fluorescent lighting was eliminated. Although no effect was obtained for pupils selected for high levels of hyperactivity.

Overall results from this study support a call for additional field based and laboratory research into the effects of color, light and color/light combinations. Findings regarding the beneficial effects of ultraviolet light and reduction of electromagnetic radiation in the school environment support strong recommendations for further study of these effects.

Exposure to ultraviolet light in the amounts used in this experiment reduces tooth decay and appears to be beneficial for students' health. Although full spectrum lighting is known to have more accurate color rendition capability, specific recommendations regarding optimal lighting or color specifications for schools cannot be made on the basis of this single study.

COLOR AND LIGHT EFFECTS ON STUDENTS' ACHIEVEMENT, BEHAVIOR AND PHYSIOLOGY

TABLE OF CONTENTS

Acknowledgements i

Abstract ii

Table of Contents iv

List of Tables vii

List of Figures xi

Chapter 1 Background and Definition of the Study

Background 1
General Problem 1
Assumptions 2
Research Questions 2
Significance of the Study 2
Delimitations 3
Limitations of the Study 3
Overview of Chapters 3

Chapter 2 A Review of the Literature

Lights and Color: Elements of the School Environment 4
Light and Related Studies 4
Vitamin D. Synthesis 5
Calcium Absorption 6
Psoriasis Treatment 6
Synchronization of Internal Clocks 7
Hyperbilirubinemia 8
Other Light Related Studies 8
Psychological Effects of Sunlight 12
Adverse Effects of Sunlight 12
Color and Related Studies 13
A Study Framework 16
Chapter Summary 18

TABLE OF CONTENTS (CONTINUED)

Chapter 3 Research Design and Procedures

General Research Designs 19
Measuring Cognitive Development and Academic Achievement 20
Measuring Physiological and Attitudinal Changes 20
Light as an Independent Variable 22
Color as an Independent Variable 22
Research Questions 25

Chapter 4 Findings

Question 1.1 - The Effect of Student Mental Ability and Achievement Levels 26

  Grade One Results 26
  Grade Two Results 26
  Grade Three Results 34
  Grade Four Results 34
  Grade Five Results 46
  Grade Six Results 46

Question 1.2 - Attitudes Toward School Subjects 59

Question 1.3 - Misbehaviors Warranting Disciplinary Action 63

Question 1.4 - Absences Due to Illness 70

Question 1.5 - Refractive Eye Problems 70

Question 1.6 - Blood Pressure 75

  Results for Staff 75
  Results for Students 75

Question 1.7 - Pre-Adolescent Mood States 88

Question 2.0 - Electromagnetic Radiation Emmissions Grade Three Behavior 90

TABLE OF CONTENTS (CONTINUED)

Question 3.0 - Noise Levels in the Color/Light and Control Schools 91

- Measuring Sound 91
- Sound Level Measurements 91
- Equipment Utilized 92
- Environment 92
- Results and Conclusions 92

Question 4.0 - Ultraviolet Light and Dental Caries 98

Question 5.0 - Ultraviolet Light and Absences Due to Illness of Grade Five Students 103

Chapter 5 Conclusions, Discussions, Recommendations and Implications 104

Bibliography 109

Appendices 114

A School Subjects Attitude Scales 115

B Pre-Adolescent Mood Variation Study 117

C Electromagnetic Radiation and Student Off-Task Behavior Study 126

D Dental Study In-press 166

E Measurement of Ultraviolet Light from Flourescent Lighting in Wetaskiwin Schools - 15 September, 1982 167

F Illuminance Survey - Schools of the Wetaskiwin School District No. 264. 171

LIST OF TABLES

Table

1 Pretest and Posttest Administration For 1981-82 and 1982-83 School Years By Grade and Date 21

2 Summary of Grade One Cognitive Achievement Results: Treatment Over Time 27

3 Grade One Reading Test Results 28

4 Grade One Mathematics Test Results 29

5 Summary of Grade Two Cognitive Development Results: Treatment Over Time 30

6 Grade Two Mental Ability Test Results 31

7 Grade Two Math Achievement Results 32

8 Grade Two Reading Test Results 33

9 Summary of Grade Three Cognitive Development Results: Treatment Over Time 35

10 Grade Three CTBS Vocabularly Test Results 36

11 Grade Three CTBS Reading Test Results 36

12 Grade Three CTBS Math 1. Test Results 37

13 Grade Three CTBS Math-2 Test Results 38

14 Grade Three CTBS Total Math Test Results 39

15 Summary of Grade Four Ability and Achievement Test Results: Treatment Over Time 40

16 Grade Four Lorge-Thorndike Verbal Test Results 41

17 Grade Four Lorge Thorndike, Non-Verbal Test Results 42

18 Grade Four - CTBS Vocabularly Test Results 43

19 Grade Four - CTBS Reading Test Results 44

LIST OF TABLES CONTINUED

Table

20 Grade Four - CTBS Math Test Results 45

21 Summary of Grade Five Ability and Achievement Test Results: Treatment Over Time 47

22 Grade Five Lorge Thorndike, Verbal Test Results 48

23 Grade Five Lorge Thorndike, Non-Verbal Test Results 49

24 Grade Five CTBS Vocabularly Test Results 50

25 Grade Five CTBS Reading Test Results 51

26 Grade Five CTBS Math Test Results 52

27 Summary of Grade Six Ability and Achievement Test Results: Treatment Over Time 53

28 Grade Six Lorge Thorndike, Verbal Test Results 54

29 Grade Six Lorge Thorndike, Non-Verbal Test Results 55

30 Grade Six CTBS Vocabularly Test Results 56

31 Grade Six CTBS Reading Test Results 57

32 Grade Six CTBS Math Test Results 58

33 Overall Attitudes Toward School Subjects 60

34 Pupils' Perceptions of Usefulness of School Subjects 61

35 Pupils' Perceptions of Difficulty of School Subjects 62

36 Means Tables - Incidence of Discipline; Comparison By School 66

37 Results For Aggression: Treatment Over Time 67

LIST OF TABLES CONTINUED

Table

38 Results For Destructive Behavior: Treatment Over Time 68

39 Results For Habitually Desruptive Behavior: Treatment Over Time 69

40 Summary of Absence Statistics 72

41 Significance of the Difference Between Percentages: Pairwise Comparisons of Student Absences Between Schools 73

42 Results of Instaline Vision Tests 74

43 Summary of Student Blood Pressure Means By School Time Of Day and Time of Year 77

44 Summary of Student Blood Pressure Means By School Fall - Spring Comparisons 78

45 Results For Student Blood Pressure - Fall Treatment Over Time of Day Between Schools 79

46 Results For Student Blood Pressure - Winter Treatment Over Time of Day Between Schools 80

47 Results For Student Blood Pressure - Spring Treatment Over Time of Day Between Schools 81

48 Results For Student Blood Pressure - Per Cent Of Change in A. M. Measures Fall to Spring: Treatment Over Time Between Schools 82

49 Results For Student Blood Pressure - Per Cent Of Change in P. M. Measures Fall To Spring: Treatment Over Time Between Schools 83

50 Cumulative Distribution of Sound Levels Comparison Between Color/Light and Control Schools, Wetaskiwin 94

51 Comparison Between Monitored Sound Levels At Color/Light And Control Schools, Wetaskiwin 95

LIST OF TABLES CONTINUED

Table

52 Percentage of Sound Level Distribution 97

53 Caries Incidence With Standard Deviation of Children In Ultraviolet Light Study Over 22 Months Including Caries I 99

54 Caries Incidence With Standard Deviation Of Children in Ultraviolet Light Study Over 22 Months Excluding Caries I Findings 99

55 Analysis of Variance For Deft Utilizing Both Caries Indices 100

56 Analysis of Variance For Defs Utilizing Both Caries Indices 101

57 Oral Hygiene Index With Standard Deviation of Children In Ultraviolet Light Study Over 22 Months 101

58 Gingivitis Index With Standard Deviation Of Children In Ultraviolet Light Study Over 22 Months 102

LIST OF FIGURES

FIGURES

1. Comparison of the Distribution Curves of Vita-Lite/Cool White Light 9

2 Independent Variables of Color Light Combinations 17

3 Comparison of the Distribution Curves of Vita-Lite, Cool White Light and Natural Outdoor Light 23

4 Colors and Their Computer Numbers (Glidden) 24

5 Disciplinary Problem Recording Form 64

6 Absences Due to Illness 71

7 Morning Systolic Blood Pressure Wetaskiwin Students 84

8 Afternoon Systolic Blood Pressure Wetaskiwin Students 85

9 Morning Systolic Blood Pressure Wetaskiwin Teachers 86

10 Afternoon Systolic Blood Pressure Wetaskiwin Teachers 87

11 Cumulative Distribution of Sound Levels in Wetaskiwn Schools 96

12 A Model for Future Environmental Research 108

CHAPTER 1

BACKGROUND AND DEFINITION OF THE STUDY

Background

Each succeeding generation in our western world seems to spend more time in buildings and under the influence of man-made environments than its preceding generation. While people still spent some of their time out of doors in the natural environment there may have been little concern, but many people now spend most of their time in man-made environments. Certainly, children in the northern climates spend almost all of the winter daylight hours inside school buildings.

The man-made environments in which we now live and work were changed significantly in the early 1970s as a result of the energy crisis. The energy crisis sparked significant interest in energy conservation in schools with the result that in many schools windows were eliminated, light levels were reduced, ventilation air levels were lowered and interior designs were subject to traditional decors. Concerned groups--sometimes professionals, sometimes parents, sometimes teachers, and sometimes students--began to decry these marked changes to the school environment. Various concerns and alternatives were raised such as increasing the use of windows, using natural light in classrooms, using sunlight-simulating light sources, choosing different colour schemes, reducing air pollution in buildings, and reducing alleged radiation hazards.

Providing optimal conditions for learning is a responsibility shared by educators, facility planners and maintenance personnel, school trustees and others. Considerable resources and effort are expended each year in developing curricula and instructional materials, and in activities such as providing in-service opportunities to enable teachers to maintain and improve the quality of instruction. Government departments, educators and trustees have shared responsibility for these developments and activities.

The experimental study described in this report addressed factors in the learning environment which differ from the traditional focus on curriculum and instruction. The physical setting in which learning and teaching take place received attention; specifically, colour and light in elementary schools. Those who initiated, funded and conducted the experiments feel that these aspects of the physical environment merited attention. Studying the effects of variations in colour and light was attractive because of the relative ease with which modifications of these could be made. Changing colours in schools can be accomplished during the regular redecoration schedule. Changing light fixtures, while expensive, would be cost-effective provided that sufficient educational benefit could be demonstrated.

General Problem

The following general problem or question served to provide direction and focus for this study.

What are the effects of light and/or colour on elementary school students in a northern climate?

Assumptions

A number of assumptions underlie the study and the way it was conducted.

(1) Elementary school students in Wetaskiwin are: (a) representative of students in Alberta and (b) students in each of the four school catchment areas under study in Wetaskiwin are statistically comparable.

(2) Elementary schools in Wetaskiwin are comparable to other schools in Alberta in terms of general colour schemes, size, lighting levels, window area and other physical features which could influence the outcomes of the study.

Research Questions

The research questions addressed by this study are:

1. For elementary school students what will be the effects over one year attributable to each of simulated natural light, and prescribed colours and the experimental light/colour combination in the school environment on the following: mental development, scholastic achievement, attitudes toward school subjects in grades five and six, misbehaviours warranting disciplinary action, absences due to illness, refractive eye problems, blood pressure, and incidence of dental caries?
2. For grade five students what are the effects, over one year and two years, attributable to simulated natural lighting (with trace amounts of ultra violet) on the incidence of dental caries?
3. For grade five students what are the effects of ultraviolet light on absences due to illness?
4. For grade three students what are the effects of eliminating electromagnetic radiation on off-task behaviors?
5. What are the effects of the prescribed color/light combination on noise levels?

Significance of the Study

A review of the literature suggested that things like students' ability to learn, students' ability to pay attention, students' general health and a number of other factors were influenced by both light and colour. The significance of this study lies in it's ability to replicate and confirm the findings reported in the literature. If the findings are confirmed then there is great potential for improving the learning environment and perhaps even improving children's ability to learn by means of such simple modifications as painting the walls particular colours and installing suitable light sources.

Delimitations

The study was delimited to include only those students in grades one to six in four elementary schools in Wetaskiwin, a small city in Central Alberta.

Limitations of the Study

Outcome indicators were limited to measures that could either be recorded on pencil and paper tests, to observations, and to such physiological measures as blood pressure and dental cavity development. No attempts were made to obtain measures of hormone levels or endocrine system activity in that these would have required complex blood sampling and analysis.

The separate effects of cool, relaxing colors and warm, stimulating colors were not determined in this experiment. For aesthetic reasons warm and cool colors were used in combination as the prescribed colors.

Overview of Chapters

Chapter one introduces the reader to some of the issues surrounding light and colour and lists the questions which the study attempted to answer.

Chapter Two contains a literature review of research findings on light and colour together with a conceptual framework, and a chapter summary.

Chapter Three contains the research design. Topics such as research questions, the study population, the data collection design, and data analysis strategy are included together with a chapter summary.

Chapter Four contains the findings.

Chapter Five contains the conclusions, recommendations and implications. A detailed bibliography is also included with this report.

CHAPTER 2

LIGHTS AND COLOR: ELEMENTS OF THE SCHOOL ENVIRONMENT

Sunlight is by far the most common type of natural light. Other types include lightning, the auroras, and bioluminescence. Sunlight may be received as direct light or as skylight (diffused light). For most people, some part of each day is spent under the influence of sunlight. However, as our society becomes more urbanized, the amount of time spent daily under the influence of sunlight is decreasing. More and more people are spending more and more of their time under the influence of artificial light.

Of direct concern to this literature review is the school environment--the lighting and colors used in classrooms where students are studying. Research related to three major light sources are examined in this review: natural lighting, incandescent lighting, and fluorescent lighting (cool-white and full spectrum). Other light sources including mercury vapor, metal halide, and high pressure sodium have relatively poor colour rendition characteristics and are generally not used in classrooms. For that reason they are not discussed in this section. It is also important to differentiate between discussions about light sources and discussions about well designed lighting systems. Because the latter is already a well documented science it will not be discussed here but rather attention will be given to light sources. Because of its close relationship to light, the literature on color and its effects on people will also be reviewed.

Light and Related Studies

Sunlight is the form of natural lighting which nurtures most living things. Photosynthesis (the ability of plants to use sunlight in manufacturing food) and phototropism (the tendency of plants to grow towards light) are two light-related processes that are well understood. The effects of light in vision are also well understood. Non-visual effects of light on people are not so well understood. Some of the known or suspected effects of light on people are discussed in later sections of this review but before such a discussion takes place, it is useful to discuss the nature of sunlight.

When sunlight passes through a raindrop, a rainbow is formed. Sunlight passing through a prism produces the same effect. While sunlight appears to be "white" light, the rainbows produced by raindrops or prisms suggest that sunlight contains many colors. The range and intensity of these colors is referred to as the spectrum of sunlight. Sunlight reaching the earth's surface consists of energy in wavelengths ranging from 300 nanometers (nm) to 825 nanometers (Thorington, Parascandola & Cunningham, 1971: 34). For the most part vision is a response to light energy reflected from objects in wavelengths ranging from 400 nm to 770 nm. Wavelengths shorter than 400 nm fall into the ultraviolet range while wavelengths longer than 770 nm are more readily sensed as heat (infrared). Between 440 nm and 770 nm the energy intensity of sunlight is quite uniformly distributed.

Because sunlight contains all colors in relatively uniform amounts, all colors are equally visible when viewed under sunlight. Natural light, therefore, serves as the reference for comparing the color rendition characteristics of other light sources, with natural light having the maximum or reference color rendition index (CRI) of 100.

Aside from enabling vision, natural light has some interesting effects on animals and people. Some of these effects are physiological and some are psychological. The scope of these effects are highlighted by Dantsig, Lazarev, and Sokolov (1967:225) who say:

> If the human skin is not exposed to solar radiation (direct or scattered) for long periods of time, disturbances will occur in the physiological equilibrium of the human system. The result will be functional disorders of the nervous system and a Vitamin D deficiency, a weakening of the body's defenses and an aggravation of chronic diseases.

Wurtman and Neer (1970) report that:

> The indirect effect of light about which most information is available is, of course, vision. Retinal responses to environmental lighting also mediate an expanding list of neuroendocrine hormonal effects. These include control of pubescence, ovulation, and a large number of daily rhythms.

An article in the CEFP Journal (1979:16) quotes Faber Birren as stating:

> The action of ultraviolet radiation intensifies enzymatic processes of metabolism, increases the activity of the endocrine hormone system, promotes the immunobiological responsiveness of the body and improves the tone of the central nervous and muscular system.

A number of the light-related physiological and psychological processes which have been identified are discussed below.

Vitamin D Synthesis

Rickets was first described in England in 1650--about the time of the introduction of the use of soft coal. The use of soft coal (and its related smog) spread quickly through Europe and with a concurrent increase in the incidence of rickets. In 1909 Schmorl did post-mortems on 386 children that had died with rickets (Loomis, 1970:5). He noted that deaths declined in the spring and increased in the fall. Healings of rickets at the same time increased in the spring and declined in the fall. By 1919 researchers had reached the conclusion that sunlight was the key to the cure of rickets. Kurt Huldschinsky, a pediatrician in Berlin in 1919, discovered that artificial ultraviolet was effective in curing rickets (Loomis, 1970:6). Currently it is accepted that ultraviolet irradiation or regular doses of Vitamin D can prevent or cure rickets.

Robert Neer (1975:409-416) describes the relationship between ultraviolet irradiation (at wavelengths shorter than 310nm) and the synthesis of Vitamin D. The process he describes involves synthesis of a precursor of Vitamin D in the skin of humans when irradiated by ultraviolet light and he further notes that:

> The amount of 7-dehydrocholestrol present in three square inches of human skin would supply the daily requirements of Vitamin D_3 if completely converted (p. 412).

He also affirms that:

> Childhood rickets is readily cured by 2.5 - 7.5 micrograms of Vitamin D daily, equivalent to approximately 2 to 4 glasses of fortified milk, prolonged exposure to winter sunlight, or five minutes exposure to artificial ultraviolet radiation equivalent to summer sunlight at 36 latitude i.e., the southern United States (p. 413).

Holick, et al (1979:54-63) discuss the process whereby Vitamin D_3 is synthesized in the skin under UV exposure.

Calcium Absorption

Neer, et al (1971) describe a study involving male residents at the Chelsea Massachusetts Soldiers' Home in which full-spectrum fluorescent lighting was used. The full-spectrum fluorescent lights delivered about 5 percent of their total radiant energy in the ultraviolet range (290 nm - 380 nm) but the level of illumination was approximately 10 times greater than in the control setting. (550 footcandles vs 30-50 footcandles). The conclusion of the study was that:

> . . . Relatively small amounts of ultraviolet light can stimulate calcium absorption among elderly men who have no exposure to sunlight and eat a diet containing few foods fortified with Vitamin D.

Neer (1975:413) further concludes that:

> The winter decrease in adult calcium absorption is prevented or reversed by daily exposure to artificial sunlight in doses equivalent to 15 minutes' strong natural summer sun at 36 N. (Kansas City, for example).

Psoriasis Treatment

Bickford (1981:19-13) reports that:

> Repeated PUVA (psoralen and UV-A at 320-400 nanometers) exposures cause disappearance of lesions of psoriasis in most patients. Ten to thirty treatments given twice weekly usually are adequate to achieve clearing. Weekly maintenance treatments keep most psoriatics free of evidence of their disease.

Synchronization of Internal Clocks

A great deal of research has been undertaken into the effect of environmental lighting on the biological function of animals and people.

Richard Wurtman (1968:5-6) summarized the current research and declared:

> One fact seems certain: Light has biologic effects, and they may be very important to the health of the individual. Data have been available for some time showing that environmental lighting influences 'well-being', performance, and other biologic phenomena which are difficult to measure. Recently evidence has begun to accumulate that light exerts specific biologic effects, which are easily measured and reproduced in the experimental laboratory. These effects are of two kinds: (1) Those which modify the individuals endocrine, hormone and metabolic state, and which are mediated through the retinas; and (2) Those which result from a direct action of light on the skin (e.g., stimulation of Vitamin D production, skin tanning, photolytic dissociation of bilirubin).

After further research, Dr. Wurtman (1969:36) reported that on:

> Reviewing the entire equation, we see that light input (or its absence) controls pineal synthesis and secretion of the hormone melatonin. This hormone influences the functional activity of a number of glands, probably by direct action on brain centres that control the anterior pituitary.

He (Wurtman, 1969:37) continues by noting that:

> One aspect of biologic responses to light that seems to deserve immediate study concerns the identification of that portion of the energy spectrum capable of influencing neuroendocrine functions in humans.

Wurtman and Weisel (1969:1220) studied the effects of cool-white and Vita-Lite (full-spectrum) light on a group of rats.

> By the time the animals attained the age of 50 days, there were considerable differences in the weights of several organs. . . . The testes and ovaries of rats born and maintained under Vita-Lites were significantly larger than those of animals exposed to the cool-white source, while the spleens of both males and females were significantly smaller for both sexes. Female rats housed under Vita-Lites had larger hearts and pineals than females exposed to the cool-white source, while males housed under Vita-Lites had larger adrenals than animals of the same sex kept under the cool-white fluorescent source.
>
> These data provide clear evidence that at least some neuroendocrine effects of environmental lighting display an action spectrum, i.e., the effects of a particular light source on

> gonadal growth depends upon its spectral characteristics. . . . The photo receptive units which mediate the neuroendocrine control of the ovary either must be sensitive to differences in the proportions of, for example, blue to yellow light, or must have the capacity to respond to long-wave ultraviolet irradiations as well as to visible light.

Hyperbilirubinemia

Bilirubin is formed by the breakdown of hemoglobin and is normally excreted after undergoing a chemical change in the liver. In newborn infants (and especially premature infants) the bilirubin excreting process may not be fully functional. A rise in the level of bilirubin can lead to jaundice. If untreated the excessive bilirubin can effect the brain and permanent neurological damage can result.

Thorington, et al (1971), Hodr (1971) and Lucey (1972) cite numerous studies involving the use of phototherapy in treating hyperbilirubinemia. As an alternative to exchange transfusions, irradiation with light (especially blue light in the 440 nm to 470 nm range) has proven effective and is considered standard treatment in many hospitals. (Wurtman 1975; 476) indicates that full spectrum light (which has a strong blue component) is equally effective.

Other Light-Related Studies

While natural light may at times be used for lighting the interior of buildings, various factors, including the seasonal variations in natural light intensity and duration, make it mandatory that some form of artificial lighting be used to augment natural lighting. The most common forms of artificial lighting are incandescent and fluorescent.

Incandescent light is produced by heating a tungsten wire in an inert gas. The radiant energy from incandescent lamps is similar to that of candlelight or firelight and tends to fall in the red end of the visible spectrum. The color rendition index (CRI) is quite low, although the light does tend to be very flattering to skin tones.

Fluorescent light is produced by electron bombardment of a phosphor coating on the interior of the light tube. These electrons are released as a result of other electrons emitted from cathodes and bombarding mercury vapor contained in the tube. To some extent the color characteristics of fluorescent lights can be controlled through the mixing of phosphers. Cool-white light, often referred to as the standard fluorescent light has a spectrum as shown in Figure 1 and a color rendition index (CRI) of 68. The spectrum of full-spectrum lights, with a CRI of 91, is also shown in Figure I. As can be seen in Figure I, full-spectrum lights may also contain significant amounts of energy in the ultraviolet range. it is important to note that the effects of the UV omitted by full-spectrum lamps are obtained only when the lamps are mounted in specially designed luminaires that are equipped with UV transmitting lenses. Conventional white painted luminaires and ordinary acrylic lenses absorb virtually all of the light energy emitted in the UV range.

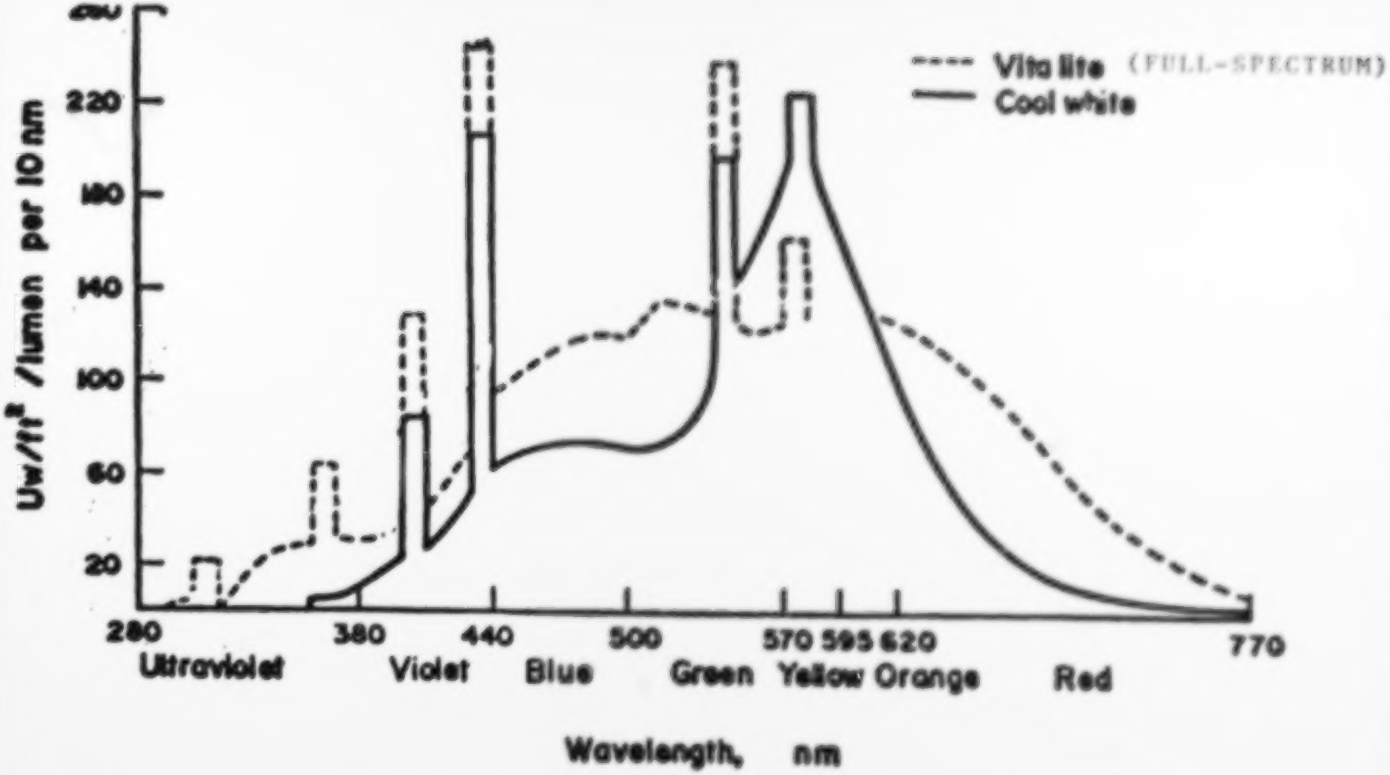


Fig. 1. Comparison of the distribution curves of Vita-Lite/cool white light

I.M. Sharon, R.P. Feller and S. W. Burney

Zamkova and Krivitskaya (1966) augmented regular fluorescent light with ultraviolet suntan lamps in a controlled experiment involving school children. They reported several findings. Among them were: increased levels of working ability and resistance to fatigue, improved academic performance, improved stability of clear vision, and increased weight and growth in the experimentally irradiated group over the control group.

Volkova (1967:109-111) studied the effects of ultraviolet supplements to general lighting in a factory. As compared to a control group, the experimental group demonstrated decreased permeability of skin capillaries, increased white cell activity, and reduced catarrhal infections and colds.

Smith (1976:205) noted that Russian children in Murmansk regularly received UV treatments during the sunless winter season.

Laszlo (1969) reported that certain snakes and lizards that had been notoriously difficult to keep alive in captivity responded favorably when the lights they were exposed to were changed to full-spectrum lights (Vita-Lites).

Himmelfarb, Scott and Thayer (1970:1013-1014) reported that light from Vita-Lite (full-spectrum) bulbs was significantly more effective in killing bacteria than light from standard cool-white bulbs.

Sharon, Feller, and Burney (1971:1427) reported that:

> Golden hamsters, exposed to fluorescent light which simulated both the visible and ultraviolet spectrum of natural outdoor light, had one-fifth as many caries (tooth caries) as animals exposed to conventional fluorescent light. Total body weight, gonad and submandibular gland weights were greater for the animals raised under the simulated natural light.

MIT Reports on Research (1970) carried an article describing a study of elderly people under cool-white and simulated natural light conditions. The article stated:

> The group of 10 living under the simulated sunlight absorbed twice as much calcium into their systems as did the 10 exposed to fluorescent light (cool-white). The amount of ultraviolet light needed to produce this effect was much below the amount needed to cause even a trace of sunburn. It was equivalent to the exposure one might obtain by taking a 15-minute lunchtime walk in Boston or Washington in the early spring.

Maas, Jayson and Kleiber (1974 a, b) report a study comparing the effects of full-spectrum to cool-white light on a group of students at Cornell University. The findings of the study indicated that students studying under full-spectrum lights had a smaller decrease over time in critical flicker fusion (the frequency of intermittent stimulations of the eye at which flicker disappears) and an increase in visual acuity. Students studying under cool-white illumination "became less lively or more lethargic after four hours under the cool-white light".

Mayron, Ott, Nations and Mayron (1974:44) found the:

> . . . Use of full spectrum fluorescent lighting and radiation shielding lead foil shields to shield against stray soft x-rays emanating from the fluorescent light cathode decreased the hyperactive behavior of students in two first grade rooms as compared to the students in two control rooms with standard cool-white fluorescent lighting.

In another study, Mayron and Kaplan (1976:83) used bean seeds as a check for radiation emanating from fluorescent lights that fell outside the normal light spectrum.

> Using an assay system based upon the germination time of bean seeds, growth of root, stem and leaves, and negative tropism of bean seedlings and plants, influence other than visible light was demonstrated to be emitted from fluorescent lamps and fixtures, most notably at the electrode ends of the lamps and from the ballast. These biological effects appear to be blocked by grounded aluminium screening used as shielding, suggesting the electromagnetic nature of the influence.

Colman, Frankel, Ritvo and Freeman (1976:160) also reported a study in which it was concluded that:

> . . . The fluorescent background illumination increased the amount of repetitive behaviors in six autistic children.

Painter (1977:181-184) describes a small-scale study that compared the effects of incandescent and fluorescent lighting. When exposed to incandescent lighting in the classroom the hyperactivity behavior of a class of nine children, variously described as autistic or emotionally disturbed, decreased. When standard fluorescent lights were replaced, hyperactive behavior returned to normal levels.

Using time-lapse photography, Ott (1976:22-27) studied the effects on children of full-spectrum fluorescent lights as compared to standard cool-white lights. The full-spectrum lights had lead shields over the cathodes to stop the radiation of suspected soft x-rays. He concluded that:

> Under improved lighting conditions, using full-spectrum fluorescent tubes with lead foil shields over the cathode ends to stop soft x-rays, children's behavior in the classroom showed dramatic improvement (p. 26).

K. D. O'Leary, A. Rosenbaum and Hughes (1978:285-289) have criticized the rigor of the study by Maas, Jayson and Kleiber and that of Mayron, Ott, Nations and Mayron. In a more vigorous replication of these studies they concluded that there is no difference in the reaction of hyperactive children under either fluorescent lighting simulating daylight (full-spectrum) or the standard energy-efficient fluorescent lighting (cool-white) commonly used in schools and offices. Moreover, they found evidence that full-spectrum lighting led to increased eye fatigue because there were greater decreases in critical flicker fusion measures under full-spectrum light than under cool-white light over the duration of their study.

Psychological Effects of Sunlight

Relatively few studies have been undertaken into the psychological effects of sunlight. One study conducted in England by Longmore and Ne'Eman (1974: 24-29) provides some interesting insights. For example:

> . . . Of the people interviewed in working places such as schools, offices and hospitals, two-thirds (64 percent) considered sunshine inside buildings to be a pleasure and one-third (31 percent) as a nuisance (p. 27).

As a rule, those who liked sunlight in buildings did so because they felt it provided pleasant light, improved the appearance of interiors, provided warmth, and provided therapeutic effects. Those who disliked it did so because sunlight caused fading and because it provided thermal and visual discomfort (high contrast and glare).

Sunshine in buildings is most appreciated by those occupants who can protect themselves against the unpleasant effects of sunshine either by shading or by simply moving away from the sun. In schools or offices we find much more confined activities. The occupants of these buildings spend a great deal of time in fixed sitting positions, with a limited range of directions of view. Thermal, or, even more often, visual discomfort may be caused by exposure to direct sunlight.

The study authors (Longmore and Ne'Eman 1974:29) conclude by stating:

> The main design implications of these findings are that buildings should be designed to admit as much sunshine as possible. On the other hand they should be provided with adequate and flexible shading facilities. This will provide occupants with full control of the penetration of sunshine to meet climatic and human demands.

Adverse Effects of Sunlight

Excessive exposure to the ultraviolet component of sunlight can have adverse effects. The more common effects are sunburns, skin aging, and skin cancer. Prolonged exposure to ultraviolet light can also cause damage to the lens of the eyes. Bickford (1981:19-3) says:

> . . . Some investigators are coming to believe that all wavelengths below 400 nanometers (the ultraviolet region of the spectrum) should be excluded, where possible, from the eye, especially since these wavelengths can be easily eliminated by inexpensive sunglasses and contribute nothing to visual perception.

He (Bickford, 1981:19-5) continues by noting:

> The only known benefit of ultraviolet radiation of skin is the production of Vitamin D from precursor chemicals which are formed in the skin.

Color and Related Studies

As with light, there are studies which suggest that color may have a marked effect on people and their behavior. Wolfarth (1957; 1958) conducted early experiments which demonstrated that color has a measurable and predictable effect on the autonomic nervous system.

Hanlon (1979:89-90) makes reference to several studies of the effects of color.

> Color and touch (including temperature and humidity) are two components in the classroom climate that usually are overlooked or ignored unless they cause discomfort.
>
> A number of experiments have shown that people feel warmer in some rooms than in others although the physical temperature is exactly the same. The feeling of warmth can be added to a room through the use of red, yellow, orange, and rich brown colors in furniture, bulletin boards, and carpets. Low ceilings, about ten feet or less, with incandescent lighting or soft, warm table lights in small, individual work areas, increase the feeling of "warmth". Generally, also pleasant is a well-filled room of comfortable furniture organized by function. If filing cabinets or metal bookshelves must be in the classroom, they can be grouped together visually, as well as functionally, as a resource-storage unit. If their surface is blemished or unsightly, they can be spray painted or used for vertical display of posters or pictures. The rest of the room can be arranged into individual, small-group or large-group areas.
>
> By contrast, if your problem is one of heat rather than cold, you can "cool" your room, again by color--blue, green, pale neutrals, and white--with bare floors and high ceilings. The lights should be fluorescent and the room quiet with optimum ventilation and sparse furnishings. The "cool" effect can be achieved by a careful stress on simple lines and a minimum of visual-aural chaos. The "modern" school furnishings can be the most helpful, as the lines and shapes of the equipment are straight and plain with basic, low-contrast, smooth-textured surfaces. Graphic, bold designs, so popular now with teenagers and young adults, can be painted on one or two light walls by the students to add visual movement and rhythm without sacrificing the desired "cool" atmosphere.

The "Research Review" section of a recent CEFP Journal (1979) includes summaries of several color-related research projects.

In one of the cited studies by Garnsey:

> . . . Two adjacent committee work rooms were compared, each equivalent in size but different in color. The committee in the gray-salmon colored room accomplished more work, finished sooner, and estimated that the time passed more quickly than the committee in the gray-blue-green room. As another example, this may be best illustrated by a practical application

> in an actual situation. One particular bank was so enclosed by other structures that it was impossible to air condition the building. The interior of the bank was originally painted "institutional tan." The people commented on how hot it was in the bank. Simply by changing the color of the interior to a light blue-gray-green and by painting the interior columns white, the heat problem was reduced.
>
> The people in the bank perceived the temperature as being cooler (p. 16).

The reviewer found sufficient evidence to support the conclusion that:

> It is also possible to use color to facilitate classroom management, based on the rationale that cool colors promote a feeling of tranquility, whereas warm colors promote increased stimulation. From this psychological standpoint, hospitals, business and industries have taken advantage of proper color selection more than educational institutions have (p. 17).

The reviewer also contends that:

> Another psychological dimension of color can be found by its receding or advancing effects. Applying this to school facilities, long halls may be made to appear shorter by painting a warm color at either end. Small rooms (seminar rooms) may appear not so confining by the use of cool colors on some walls (p. 16).

Another interesting application of color theory was also cited in the review.

> Knute Rockne also must have understood how color affects moods of people. In a novel attempt to psychologically affect the opposing teams, he had the home team locker rooms painted a brilliant red (high-energy color) while the visiting team's locker rooms were painted blue, causing a restful feeling. Coach Rockne attributed a part of his success to his use of colors in the locker rooms (p. 16).

Philip Hughes (in press) makes references to several studies which focused on the role of color. Plack and Shick in 1974, for example, found the effects of color to include:

> . . . Changes in mood and emotional state, psychomotor performance, muscular activity, rate of breathing, pulse rate, and blood pressure (p. 12).

A study conducted in 1958 by Gerard (Hughes, in press) investigated the effects of colored lights on psychophysiological functions.

> Blue, red and white lights of equal brightness were each projected for ten minutes on a screen in front of 24 normal adult males. The autonomic nervous system and visual cortex were found to be significantly less aroused during blue than

> during red or white illumination. The colors also elicited significantly different feelings, with blue being associated with increased relaxation, less anxiety and hostility and red illumination being associated with increased tension and excitement. Manifest anxiety level was significantly correlated with increased physiological activities and subjective disturbance during red stimulation. He found responses in the opposite direction of quiesence and relief during blue illumination (p.12).

According to Hughes (in press) the work of Aaronson in 1971 also reported much the same effect of colors on activities and arousal.

Day (1980:5) in discussing the physical environment of a school provides some comments on the use of color.

> Color affects and influences humans of all ages. Some colors tend to stimulate, some soothe and relax, and others create fatigue, depression and irritation. For any given color there is an association that goes with it in the subconscious mind. Thus, various colors may serve definite functions in planning the school room. . . . Dark colors often produce a feeling of gloom in individuals. Color may cause emotional reactions and create feelings of coolness, warmth, size, dimension, weight and distance.
>
> Educational leaders and others responsible for school planning have often virtually ignored the value of color in the learning environment. Planners should be concerned with using proper color to influence the visual environment. Industry uses color to speed production and reduce accidents, hospitals use various shades of color to enhance the effectiveness of the surgeon and to promote faster healing for the patient. Color that is properly used certainly will contribute to an improved environment for learning.

It is also possible that color has significant cultural meanings. For example, black is the color associated with funeral and mourning in North America. In Viet Nam the color white has the same significance.

H. Wohlfarth and K. Sam (1981) conducted a study of the effects of color and light variables on a small group of severely handicapped children and their teachers. The findings indicate that during a three-week exposure to full spectrum lighting in a classroom painted in relaxing shades of blue, several measures changed significantly. For example: the systolic blood pressure of the students (both blind and sighted) dropped approximately 20 points (from 120 to 100); aggressive behaviors dropped to 56 percent of their normal levels; non-attentive behaviors dropped to approximately 23 percent of previous levels; and, teachers reported that they found the environment much more relaxing and that they were able to get more work completed by the students.

Sydoriak (1984) replicated some aspects of this present study in her study in Little Rock, Arkansas. She found a significant drop in both systolic and diastolic blood pressure in the blue classrooms.

Ott (1979:9) suggests that color has an effect on muscle strength--arm strength is greater when the subject is viewing a blue panel that when viewing a pink panel. Pellegrini and Schauss and others (1980, 1981), however, take exception to Ott's subjective measures of strength. In their own studies they concluded that subjects demonstrated only slightly more grip or leg strength when viewing blue cards than when viewing pink cards. (The increases, though statistically significant were very small.)

Pellegrini, Schauss and Miller (1981:174-181) also concluded that pink holding cells in jails did not significantly reduce aggression or have a quieting effect on occupants as had been predicted.

A Study Framework

The findings of the cited studies clearly define the effects of light in establishing and maintaining physiological functions and balances. As Dr. H. Newbold (1978:234) has concluded, "Light is nourishing." Not as clearly defined, however, are the effects that light and color might have on the performance and behavior of people.

The relationship of light to the physical well-being of people is not surprising inasmuch as a naturally-lit environment was the normal environment of our ancestors. Nor are the effects of color surprising. Blues of the sky, greens of vegetation, and the earth tones were also part of man's natural environment. It may be reasonable to conclude that people will be most relaxed in environments that most clearly simulate these conditions.

The essence of the cited research may be summarized as follows:

- Light produces a number of non-visual effects in people. These effects may be in response to specific components of the light spectrum.
- Different artificial light sources have different spectra and may have varied effects on people.
- The human body appears to require regular dosages of ultra violet light (or at least a vitamin D supplement) in order to maintain an optimal state of well-being.
- Some of the research suggests that full-spectrum lamps are superior to standard cool-white lamps -- their use has been linked to improved student behavior and/or achievement.
- Color has an affect on people. Cool colors (especially blue) tend to contribute to reduced blood pressure and relaxation. Warm colors, (red, yellow, orange) tend to cause an elevation of blood pressure and to produce a state of alertness or readiness.
- Ultraviolet light appears to contribute to general health and well-being and to a reduction in development of dental caries.

When these findings are carefully considered, it is apparent that fruitful research may be carried out by looking at color and light effects. The following framework served to guide most of the research initiatives described in this report.

FIGURE 2: INDEPENDENT VARIABLES OF COLOR LIGHT COMBINATIONS

		COLOR EFFECTS	
		COOL COLORS (Relaxing)	WARM COLORS (Stimulating)
Light Effects	Cool-White Fluorescent		
	Full-Spectrum Fluorescent		

The independent effects of cool, relaxing colors and warm, stimulating colors could not be measured in the experiment repeated here. For aesthetic reasons each type of color appeared in a combination which was prescribed for the two schools labelled "color-only" and "color-light".

In addition to a study of effects of light, color and light/color combined, the literature review indicated a need to ask questions about the effects of ultraviolet radiation and the effects of electromagnetic shielding.

Chapter Summary. This chapter presented a review of the literature addressing color and/or light studies. Color or light were demonstrated to be environmental phenomena with potential psychological and physiological effects. The following chapter will present the general research design, the research questions addressed in the study and the specific research design used to answer each question.

Chapter four presents the results of the research and the final chapter presents a discussion of the findings, conclusions, recommendations and implications of the study.

CHAPTER 3

PROCEDURES

General Research Designs

A quasi-experimental, non-equivalent control group design was used with intact classes in four elementary schools in the Wetaskiwin School District. Independent variables in three experimental schools were color or light combinations, ultraviolet light and electromagnetic radiation. One school served as the control group. This design is used in a case which ". . . involves an experimental group and a control group both given a pretest and posttest, but without pre-experimental sampling equivalence for the two groups" (Good, 1972:386). Only a pre-experimental, static-group comparison design was possible for the investigation of mood and noise since baseline (pretest) measures of these dependent variables were not available (Good, 1972:380).

The group assignments were as follows:

School	Number	Treatment
Centennial	1	Nil - Control group
Norwood	2	Color and light (Ultra-violet component for gr. 5)
Parkdale	3	Light only (Ultra-violet) component for gr. 5)
C. B. McMurdo	4	Color only

(Note: Contennial and Norwood schools are architecturally identical twins, and were, therefore, selected as the control school and experimental school for the noise level study.)

Measuring Cognitive Development and Academic Achievement

Pretesting of students' ability and achievement levels was completed during the 1981-82 school year using standardized tests which were administered at various grade levels in all four schools. Posttesting was completed in most cases a year later, after the students had progressed a grade and following a ten month exposure to the treatment effects of color/light, light only or color only. The schedule of pre and posttesting is displayed in Table 1 as follows on the next page.

Pretest results were used to establish the comparability of groups on the measures used. In cases where equivalency of pretest measures were not obtained and where different tests were used from grade to grade, Analysis of Covariance was used to adjust posttest averages and establish statistical equivalency. Where equivalent groups were available the Repeated Measures Analysis of Variance procedure was used to determine if a significant difference existed.

During the 1982-83 school year students were exposed to the various treatments of color and/or light. Posttests were administered during this period using the instruments listed in Table 1 on the next page.

Measuring Physiological and Attitudinal Changes

All students were given Stereoscopic Vision Tests designed to test eye muscle balance and Snellen Vision Tests of visual acuity twice during the project year. Samples of ten students were selected from each of grades two and four through six for blood pressure readings which were taken two days per month in the morning and afternoon. Teachers and principals also had their blood pressure measured. Vision testing and blood pressure measurements were carried out by public health nurses.

Also, during the 1982-83 school year, student behaviors requiring disciplinary actions and absences due to illness were recorded by school staffs. Students in grades three through six were assessed with the Preadolescent Mood Scale (Schokman-Gates, 1984) and grades five and six were also assessed with the School Subjects Attitude Scales. These instruments are found in Appendices A and B. Measurements of the quantity and quality of light provided during the project year were taken and these are reported in Appendices E and F. Lastly, noise levels were measured in Schools One and Two.

Tests used to measure physiological and affective changes are summarized below:

TABLE I

PRETEST AND POSTTEST ADMINISTRATION FOR 1981-82 AND 1982-83 SCHOOL YEARS BY GRADE AND DATE

Pretest			Posttest		
Grade	**1981-82**	**Test Date**	**Grade**	**1982-83**	**Test Date**
K	Metropolitan Readiness, Form P, Level I	9/81	1		
	* KG AGS First Grade screening	5/82		Metropolitan Achievement Test Primary I, Form F	6/83
1	Otis Lennon, Primary II Form J	1/82	2	Otis Lennon, Primary II Form J	1/83
	Metropolitan Achievement Test Primary I, Form J	6/82		Metropolitan Achievement Test Primary II, Form J	6/83
2	* Otis Lennon, Elementary I, Form J	6/82	3	CTBS Form 4m	5/83
3-6	Lorge Thorndike Level D	6/82	4-6	Lorge Thorndike Level D	6/83
	C.T.B.S. Form 4M	5/82		C.T.B.S. Form 4m	5/83

* Used as covariate in ANCOVA

Test	Grade(s)	Date(s)
*Eye Refractive Test	1-6	9/82+6/83
*Blood pressure measures (Sample of ten)	2, 4-6	9/82-6/83
Discipline, Illness absence counts	1-6	9/82-6/83
Preadolescent Mood Variation tests	3-6	6/83
*Off-task behaviors measures (3 classes)	3	5/83
Noise levels measures (Schools 1 and 2)	Variable	9/83
*School Subjects Attitude Scale	5-6	9/82+6/83

* Pretest baseline data available.

Light as an Independent Variable

The light changes in Schools Two and Three were made by replacing the cool white fluorescent tubes in the classroom with full spectrum Vita-Lite. This full spectrum light comes relatively close to natural daylight, as can be observed in the spectrum graphs below (Figure 3). The visible effect of the full spectrum lighting results in better color rendition. However, unless special egg crate diffusers are installed, the white enamel and regular plastic diffusers absorb virtually all of the ultraviolet emitted by the full spectrum Vita-Lites. The only classes to be exposed to the ultraviolet supplement were the grade five classes in the light only (school three) and color/light (school two).

Color as an Independent Variable

The criteria underlying the selection of colors for Schools Two and Four were based on the phenomenological and psychological character of colors according to Leuscher (1949) and on the empirical findings of Wohlfarth and Sam (1981). The research objectives were twofold: 1) to stimulate the students toward higher achievement and performance, and 2) to counteract "teacher burnout". In order to achieve the two objectives, two main colors were selected. A warm, light yellow (73-85, Glidden) was used on the three walls the students were facing, and light warm blue (77-30 Glidden) was used for the wall and the vertical surfaces of the student desks the teachers were facing during the school day. All "blackboards" were changed from green to blue (77-18 Glidden). The colors of the control school were Dark Brown, Grey, Off White, Putty and Orange (79-88, 78-79, 71-15, 73-19, and 72-56 Glidden respectively). The reason for using the Glidden computer numbers was the availability of Glidden paint colors in both Canada and United States.

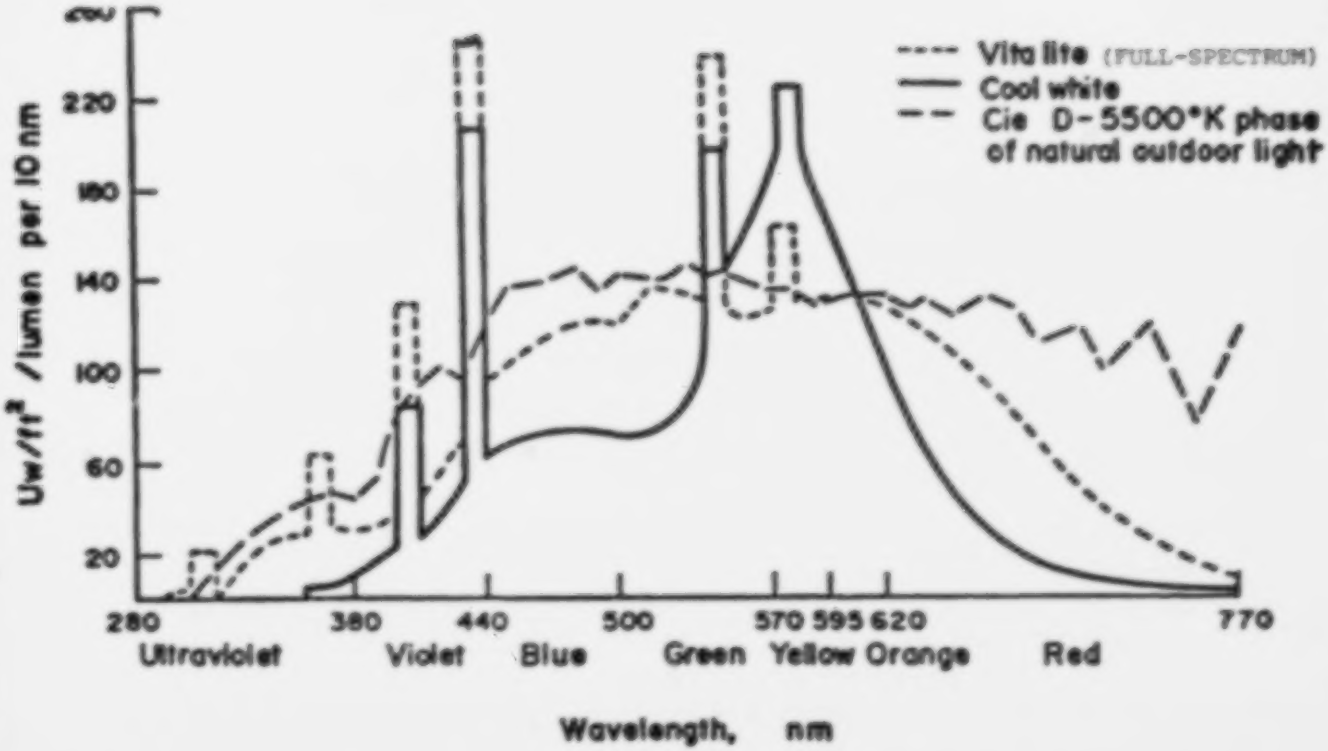
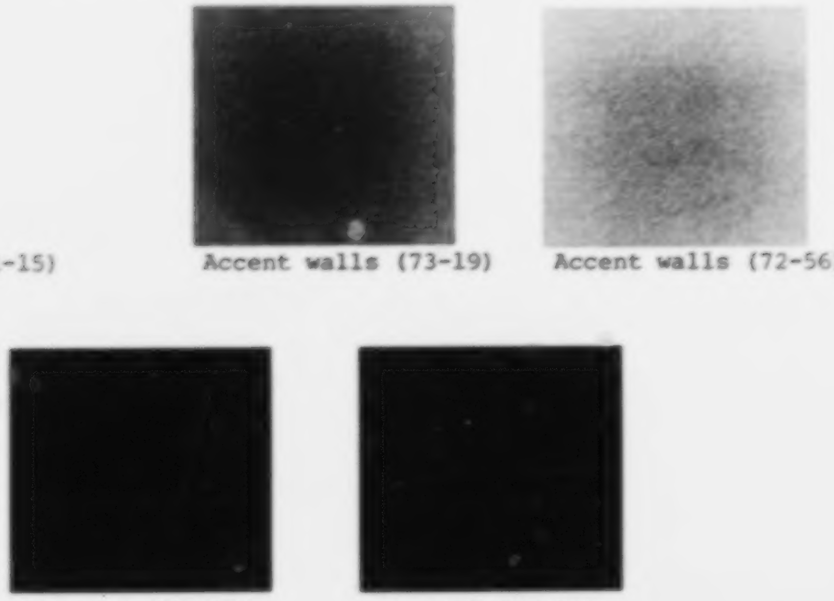


FIG. 3. Comparison of the distribution curves of Vita-Lite, cool white light and natural outdoor light.

I. M. Sharon, R. P. Feller and S.W. Burney

Figure 4. School color schemes.

Control School (Traditional Colors)



Walls (71-15)

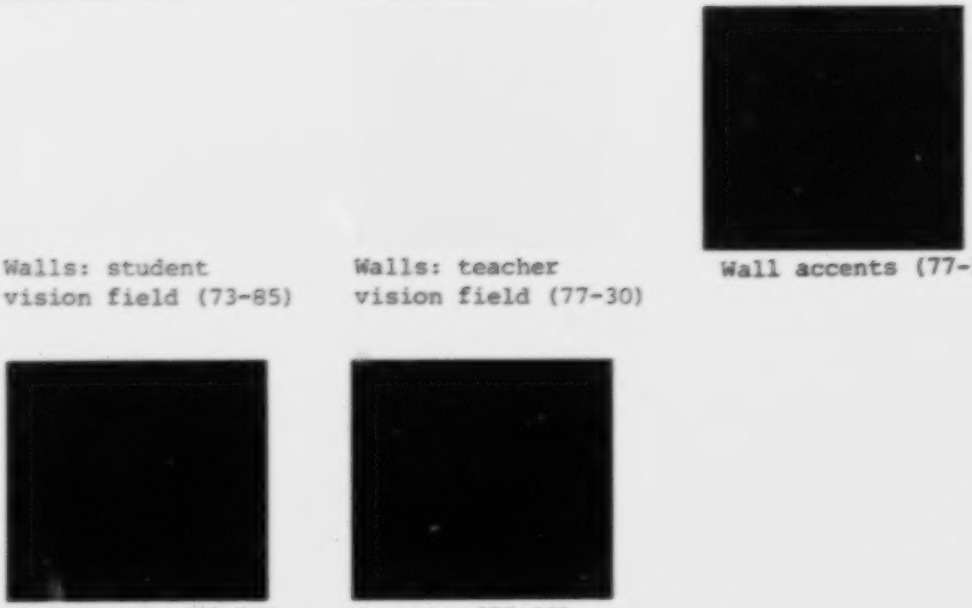
Accent walls (73-19)

Accent walls (72-56)

Carpets (78-79)

Carpets (79-88)

Experimental Schools (Psychodynamic Colors)



Wall accents (73-50)

Walls: student vision field (73-85)

Walls: teacher vision field (77-30)

Wall accents (77-34)

Chalkboards (77-18)

Carpets (78-69)

(Glidden Paint Numbers shown in parentheses)

Research Questions

The specific research questions addressed in this study were:

Question 1.0 - What are the effects of simulated outdoor light, the colors selected for this experiment and the experimental light/color combinations on the development of elementary school students in the following areas:

1.1 - student mental ability and achievement levels,

1.2 - attitudes towards school subjects,

1.3 - misbehaviors warranting disciplinary action,

1.4 - absences due to illness,

1.5 - refractive eye problems,

1.6 - blood pressure,

1.7 - pre adolescent mood variations?

Question 2.0 - What are the effects of eliminating electromagnetic radiation emitted by fluorescent lighting on the off-task behaviors of grade three students?

Question 3.0 - What are the effects of color/light combinations on library noise levels?

Question 4.0 - What are the effects of ultraviolet light (simulated natural light) over two years on the incidence of dental caries for grade 5 students?

Question 5.0 - What is the effect of ultraviolet light (simulated natural light) on absences due to illness of grade 5 students?

CHAPTER 4

RESULTS OF THE STUDY

Question 1.1 - The Effect on Student Mental Ability and Achievement Levels.

Differences in the standardized mental ability tests available at the grade one and three levels prevented direct comparisons of pre and posttest results in some cases. Where this occured or when pretest means showed the groups not to be equivalent, these test data were used as co-variates in Analysis of Covariance used to adjust posttest means and thus establish statistical equivalence. Tests for determining the statistical significance of differences were then conducted on these adjusted means. Analysis of Covariance uses the correlation between initial and final scores to make adjustments in final scores thus compensating for the differences in the initial test data (Garrett, 1966:295).

The gain scores attributable to experimental treatment over time were required to answer the research questions. The primary interest was in the effects of treatment over a time interval (i.e., treatment x time interaction effects) when the Repeated Measures Analysis of Variance procedure was used. When Analysis of Covariance was required, the treatment over time effect was reflected in the adjusted posttest means.

Results of the grade one comparisons between schools are summarized in Table 2 and are presented in detail in Tables 3 and 4.

The control school scored significantly higher than the light only school on the Metropolitan Reading and Math Tests (Tables 3 and 4). The color/light school scored significantly higher than the light only school and the color only school demonstrated no significant differences. Consequently, no support is evident that color/light combinations or light only or color only affected academic achievement of grade one students.

Grade two results revealed that the color/light school had significantly higher scores than the control school or the color only school on the Otis-Lennon ability test (Table 6). On the Metropolitan Achievement Test-Math, Table 7 reveals that the control, color/light and light only schools scored significantly higher than the color only school. On the MAT-Reading (Table 8), the light only school scored significantly higher than the color only school. This pattern of results, summarized in Table 5, suggests that there is very weak support for the conclusion that light has an effect on ability levels of grade two students and no evidence that color/light combinations or light only or color only affect academic achievement of grade two students.

TABLE 2

SUMMARY OF GRADE ONE COGNITIVE ACHIEVEMENT RESULTS: TREATMENT OVER TIME

School #	Metro Ach. Test Primary I, Form F Reading With AGS Screening Test As Co-Variate	Metro Ach. Test Math - With AGS Screening As Co-variate
1 (Control)	Significantly Higher Scores Than Light Only School	Significantly Higher Scores Than Light Only School
2 (Color-Light)	Significantly Higher Scores Than Light Only School	Significantly Higher Scores Than Light Only School
3 (Light Only)	Significantly Lower Scores Than Control And Color/Light School	Significantly Lower Scores Than Control And Color/Light School
4 (Color Only)	No Significant Differences	No Significant Differences

Conclusion:

No support is evident that color-light combinations or light only or color only affected academic achievement of grade one students.

TABLE 3

GRADE ONE READING TEST RESULTS

Analysis of Covariance

Source	D.F.	Mean Square	F
Covariate	1	2832.65	32.72 **
Treatment	3	289.95	3.35 *
Residual	77	86.58	

* $p < .05$
** $p < .01$

Post Hoc Comparisons of Adjusted Means [1]: Grade One Reading

Treatment		Adjusted Mean	Significant Differences	Subscripts
1.	Control	48.75	$1 > 3^*$	b
2.	Color-Light	51.75	$2 > 3^*$	b
3.	Light Only	42.13		a
4.	Color Only	43.79		a, b

---

[1] A pair of means which do not share a subscript are significantly different.

TABLE 4

GRADE ONE MATHEMATICS TEST RESULTS

Analysis of Covariance

Source	D.F.	Mean Square	F
Covariate	1	3078.14	41.88 **
Treatment	3	529.22	7.2 **
Residual	77	73.50	

* $p < .05$
** $p < .01$

Post Hoc Comparisons of Adjusted Means [1]: Grade One Reading

Treatment		Adjusted Mean	Significant Differences	Subscripts
1.	Control	48.43	1 > 3*	b
2.	Color-Light	55.50	2 > 3*	b
3.	Light Only	40.75		a
4.	Color Only	46.50		a, b

[1] A pair of means which do not share a subscript are significantly different.

TABLE 5

SUMMARY OF GRADE TWO COGNITIVE DEVELOPMENT RESULTS: TREATMENT OVER TIME

School #	OTIS - Lennon Elementary I, Form J.	Metro - Achievement Test - Reading	Metro - Achievement Test - Math
1 (Control)	Significantly Lower Scores Than Color/ Light School	No Significant Differences	Significantly More Gain Than Color Only School
2 (Color-Light)	Significantly Higher Scores Than Control And Color Only School	No Significant Differences	Significantly More Gain Than Color Only School
3 (Light Only)	No Significant Differences	Significantly More Gain Than Color Only School	Significantly More Gain Than Color Only School
4 (Color Only)	Significantly Lower Scores Than Color/- Light School	Significantly Less Gain Than Light Only School	Significantly Less Gain Than Control Color/Light And Light Only Schools

Conclusion:

There is very weak support for the conclusion that light affects ability levels of Grade Two students and no evidence that color/light combinations or light only affects academic achievement of Grade Two students.

TABLE 6

GRADE TWO MENTAL ABILITY TEST RESULTS

Mean Scores on the Otis Lennon Mental Ability Test
School by Time

	School	Pretest	Posttest
1.	Control	116.2	114.7
2.	Color-Light	111.7	119.5
3.	Light Only	112.6	113.6
4.	Color Only	115.3	109.2

Anova Results for Otis Lennon

Source	D.F.	Mean Square	F
Treatment	3	113.5	.36
SW	109	366.8	
Time	1	2.9	.05
Treatment x Time	3	391.8	7.20 **
Time x SW	109	53.9	

* $p > .05$
** $p > .01$

Post Hoc Scheffe Comparisons of Grade Two Otis-Lennon Means
Contrasts of Changes from Pretest to Posttest, Across Treatments

Contrast	F
2 vs. 1	8.09 *
3 vs. 1	1.08
4 vs. 1	2.62
2 vs. 4	14.83 **

* p .05
** p .01

TABLE 7

GRADE TWO MATH ACHIEVEMENT RESULTS

Mean Scores on Math: School by Time

	School	Pretest	Posttest
1.	Control	48.1	63.3
2.	Color-Light	50.9	68.2
3.	Light Only	41.0	57.7
4.	Color Only	48.9	55.5

Anova Results for Math: School by Time

Source	D.F.	Mean Square	F
Treatment	3	900.97	8.86 **
SW	106	101.65	
Time	1	9088.11	174.18*
Treatment x Time	3	286.23	5.49 **
Time x SW	106	52.18	

* $p < .05$
** $p < .01$

Post Hoc Scheffe Comparisons of Contrasts of Changes from Pretest to Posttest, Across Treatments

Contrast	F
2 vs. 1	.44
3 vs. 1	.42
4 vs. 1	9.38 *
4 vs 1, 2, 3	14.88 **

* $p < .05$
** $p < .01$

TABLE 8

GRADE TWO READING TEST RESULTS

Mean Scores on Reading: School by Time

	School	Pretest	Posttest
1.	Control	48.81	62.76
2.	Color-Light	49.29	59.71
3.	Light Only	42.54	58.15
4.	Color Only	45.95	53.38

Anova Results: School by Time

Source	D.F.	Mean Square	F
Treatment	3	425.94	1.84
SW	107	231.15	
Time	1	6547.25	120.29**
Treatment x Time	3	155.84	2.86 *
Time x SW	107	54.43	

* $p < .05$
** $p < .01$

Post Hoc Scheffe Comparisons of Contrasts of Changes from Pretest to Posttest, Across Treatments

Contrast	F
2 vs. 1	1.15
3 vs. 1	.49
4 vs. 1	5.23
3 vs. 4	8.40 *

* $p < .05$
** $p < .01$

Results for grade three from the Canadian Test of Basic Skills (CTBS) were analyzed through analysis of covariance with Otis Lennon Scores serving as the covariate. Table 9 provides summary information. Analysis of CTBS Vocabularly adjusted mean scores revealed no significant differences between experimental treatments (Table 10). Likewise, no significant differences were obtained on CTBS Reading scores (Table 11). CTBS Math 1 test results demonstrated that the control and color only school scored significantly higher than the color/light and light only schools (Table 12). CTBS Math 2 results, reported in Table 13, revealed the color only school scored significantly higher than the color/light school and the CTBS Total Math results mirrored the Math 1 results. Patterns in these results suggest that light may have a negative effect on Math achievement of grade three students. However, the overall pattern of test result analysis argues that neither color/light, light only or color only have a consistent effect on the academic achievement of grade three students.

Grade four student ability levels were assessed using the Lorge Thorndike Test which generates indicators of verbal ability and Non-Verbal ability. Achievement levels were assessed with the CTBS Vocabularly, Reading and Math tests. Analysis of the test data was accomplished through analysis of variance which revealed no significant differences between schools as indicated by treatment x time interaction effects. The conclusion drawn, therefore, is that no support is evident that light/color combinations or light only or color only affect ability levels or academic achievement of grade four students.

TABLE 9

SUMMARY OF GRADE THREE COGNITIVE DEVELOPMENT RESULTS: TREATMENT OVER TIME

School #	CTBS - Vocabulerly With Otis-Lennon I.Q. as Co-variate	CTBS - Reading With Otis-Lennon I.Q. as Co-variate	CTBS - Math 1 With Otis-Lennon I. Q. as Co-variate	CTBS - Math 2 With Otis-Lennon I. Q. as Co-variate	CTBS - Total Math With Otis-Lennon I. Q. as Covariate	Conclusion:
1 (Control)	No Significant Differences	No Significant Differences	Significantly Higher Score Than Color/Light And Light Only	No Significant Differences	Significantly Higher Score Than Color/Light Or Light Only	Light may have a negative effect on Math 1 and Math 16 - achievement. Neither color, nor light nor combinations had consistent positive influence on Math 2 achievement. Generally little support for affects of color or light on students achievement.
2 (Color-Light)	No Significant Differences	No Significant Differences	Significantly Lower Score Than Control Or Color Only School	Significantly Lower Score Than Color Only School	Significantly Lower Score Than Control Or Color Only School	
3 (Light Only)	No Significant Differences	No Significant Differences	Significantly Lower Score Than Control Or Color Only School	No Significant Differences	Significantly Lower Score Than Control Or Color Only School	
4 (Color Only)	No Significant Differences	No Significant Differences	Significantly Higher Score Than Color/Light And Light Only	Significantly High Score Than The Color/Light School	Significantly Higher Score Than Color/Light Or Light Only	

TABLE 10

GRADE THREE CTBS VOCABULARLY TEST RESULTS

Ancova With Otis-Lennon I.Q. as Covariate

Source	D.F.	Mean Square	F
Covariate	1	1772.91	67.39 **
Treatment	3	28.10	1.07
Residual	92	26.31	

* p <.05
** p < .01

TABLE 11

GRADE THREE CTBS READING TEST RESULTS

Ancova With Otis-Lennon I.Q. as Covariate

Source	D.F.	Mean Square	F
Covariate	1	5488.30	59.81 **
Treatment	3	181.03	1.97
Residual	92	91.76	

* p< .05
** p< .01

TABLE 12

GRADE THREE CTBS MATH 1. TEST RESULTS

Ancova With Otis Lennon I.Q. As Covariate

Source	D.F.	Mean Square	F
Covariate	1	1384.49	89.33 **
Treatment	3	74.69	4.82 **
Residual	92	15.50	

* $p < .05$
** $p < .01$

Post Hoc Comparisons of Adjusted Means [1]:

Treatment		Adjusted Mean	Significant Differences	Subscripts
1.	Control	19.61	$1 > 2^*$, $1 > 3^*$	b
2.	Color-Light	16.38		a
3.	Light Only	16.97		a
4.	Color Only	21.13	$4 > 2^*$, $4 > 3^*$	b

[1] A pair of means which do not share a subscript are significantly different.

TABLE 13

GRADE THREE CTBS MATH-2 TEST RESULTS

Ancova With Otis Lennon I.Q. As Covariate

Source	D.F.	Mean Square	F
Covariate	1	1408.15	71.60 **
Treatment	3	55.55	2.83 *
Residual	92	19.67	

---

* p< .05
** p< .01

Post Hoc Comparisons of Adjusted Means [1]:

Treatment		Adjusted Mean	Significant Differences	Subscripts
1.	Control	15.69		a, b
2.	Color-Light	12.69		a
3.	Light Only	14.30		a, b
4.	Color Only	18.00	4 > 2*	b

---

[1] A pair of means which do not share a subscript are significantly different.

TABLE 14

GRADE THREE CTBS TOTAL MATH TEST RESULTS

Ancova With Otis Lennon I.Q. As Covariate

Source	D.F.	Mean Square	F
Covariate	1	1406.41	100.96**
Treatment	3	64.01	4.60 **
Residual	92	13.93	

* $p < .05$
** $p < .01$

Post Hoc Comparisons of Adjusted Means [1]:

Treatment		Adjusted Mean	Significant Differences	Subscripts
1.	Control	17.92	1 > 2*, 1 > 3*	b
2.	Color-Light	14.92		a
3.	Light Only	15.85		a
4.	Color Only	19.88	4 > 2*, 4 > 3*	b

---

[1] A pair of means which do not share a subscript are significantly different.

TABLE 15

SUMMARY OF GRADE FOUR ABILITY AND ACHIEVEMENT TEST RESULTS: TREATMENT OVER TIME

School #	Lorge - Thorndike Verbal I.Q.	Lorge - Thorndike Non-Verbal I.Q.	CTBS - Vocabularly	CTBS - Reading	CTBS - Math	
1 (Control)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	Conclusion: No support is evident that light/color combinations or light only or color only effects have a relationship to ability levels on academic achievement of grade 4 students.
2 (Color-Light)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	
3 (Light Only)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	
4 (Color Only)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	

TABLE 16

GRADE FOUR LORGE-THORNDIKE VERBAL TEST RESULTS

Mean Scores: School by Time

	School	Pretest	Posttest
1.	Control	52.04	53.21
2.	Color-Light	58.13	63.00
3.	Light Only	63.56	67.44
4.	Color Only	64.31	63.77

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	1149.10	2.56
SW	71	449.55	
Time	1	191.68	4.80 *
Treatment x Time	3	53.35	1.34
Time x SW	71	39.91	

* p .05
** p .01

TABLE 17

GRADE FOUR LORGE THORNDIKE, NON-VERBAL TEST RESULTS

Mean Scores: School by Time

	School	Pretest	Posttest
1.	Control	48.54	47.15
2.	Color-Light	55.88	56.94
3.	Light Only	60.05	62.45
4.	Color Only	61.08	61.69

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	1417.36	5.98*
SW	71	237.22	
Time	1	15.91	0.36
Treatment x Time	3	21.55	0.49
Time x SW	71	43.82	

* $p < .05$
** $p < .01$

TABLE 18

GRADE FOUR - CTBS VOCABULARY TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	16.52	18.76
2.	Color-Light	20.54	23.00
3.	Light Only	20.17	22.58
4.	Color Only	21.36	24.21

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	180.26	2.88 *
SW	76	62.55	
Time	1	221.68	22.25**
Treatment x Time	3	0.60	0.06
Time x SW	76	9.96	

* $p < .05$
** $p < .01$

TABLE 19

GRADE FOUR - CTBS READING TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	30.83	37.62
2.	Color-Light	38.23	42.23
3.	Light Only	39.29	46.29
4.	Color Only	40.64	45.36

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	596.18	2.42
SW	76	246.23	
Time	1	1128.27	31.77**
Treatment x Time	3	19.98	0.56
Time x SW	76	35.51	

* $p < .05$
** $p < .01$

TABLE 20

GRADE FOUR - CTBS MATH TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	15.07	15.90
2.	Color-Light	19.21	20.79
3.	Light Only	18.17	19.42
4.	Color Only	19.14	20.71

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	164.83	4.14**
SW	78	39.77	
Time	1	62.68	7.10**
Treatment x Time	3	1.12	0.13
Time x SW	78	8.83	

* $p < .05$
** $p < .01$

Grade five results showed no significant differences on gains over time on either the Verbal nor the Non-Verbal tests of the Lorge Thorndike instrument used to assess student ability levels. Also, the CTBS Vocabularly test revealed no significant differences in gains between schools. However, on the CTBS Reading test the light only school improved significantly more than the control school and on the CTBS Math test, the color/light and color only schools scored significantly higher than the control school. There is clearly no support evident that color/light combinations or light only or color only affects grade five student's ability levels. Since there were no significant gains attained in the academic subjects in the other upper elementary grades, there is inconclusive support that color or light may affect grade five reading and math achievement.

Grade six students ability levels were assessed with the Lorge Thorndike Verbal and Non-Verbal tests. Achievement levels were measured with the CTBS Vocabularly, Reading and Math tests. Analysis of the test data was accomplished through repeated measures analysis of variance which revealed no significant differences in gains between schools on any of the test results; none of the interaction effects (time x treatment) were statistically significant. The conclusion drawn, therefore, is no support is evident that light/color combinations or light only or color only affect ability levels or academic achievement of grade six students.

TABLE 21

SUMMARY OF GRADE FIVE ABILITY AND ACHIEVEMENT TEST RESULTS: TREATMENT OVER TIME

School #	Lorge - Thorndike Verbal I.Q.	Lorge - Thorndike Non-Verbal I.Q.	CTBS - Vocabularly	CTBS - Reading	CTBS - Math	
1 (Control)	No Significant Differences	No Significant Differences	No Significant Differences	Significantly Lower Score Than Light Only School	Significantly Lower Score Than Color/Light School	Conclusion: No support is evident that color/light combinations or light only or color only affects ability levels of grade five students and inconclusive evidence that color or light affects Grade Five achievement levels.
2 (Color-Light)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	Significant Gain Over Control School	
3 (Light Only)	No Significant Differences	No Significant Differences	No Significant Differences	Significantly Higher Gain Over Control School	No Significant Differences	
4 (Color Only)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	Significant Gain Over Control School	

TABLE 22

GRADE FIVE LORGE THORNDIKE, VERBAL TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	55.19	54.00
2.	Color-Light	55.08	48.15
3.	Light Only	58.04	57.82
4.	Color Only	65.09	66.18

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	1161.92	2.46
SW	69	471.62	
Time	1	104.26	3.51
Treatment x Time	3	99.49	3.35
Time x SW	69	29.74	

* p< .05
** p< .01

TABLE 23

GRADE FIVE LORGE THORNDIKE, NON-VERBAL TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	49.05	48.81
2.	Color-Light	47.25	51.25
3.	Light Only	53.33	52.00
4.	Color Only	59.64	61.82

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	931.29	2.82 *
SW	67	330.75	
Time	1	41.04	1.35
Treatment x Time	3	44.50	1.46
Time x SW	67	30.40	

* $p < .05$
** $p < .01$

TABLE 24

GRADE FIVE CTBS VOCABULARLY TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	20.63	21.84
2.	Color-Light	18.21	19.50
3.	Light Only	20.42	22.10
4.	Color Only	21.92	26.75

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	168.20	1.32
SW	72	127.33	
Time	1	169.26	18.86**
Treatment x Time	3	25.07	2.79
Time x SW	72	8.98	

* $p < .05$
** $p < .01$

TABLE 25

GRADE FIVE CTBS READING TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	41.84	39.00
2.	Color-Light	36.64	36.07
3.	Light Only	41.36	44.97
4.	Color Only	43.33	45.75

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	434.46	1.43
SW	72	304.75	
Time	1	14.28	0.61
Treatment x Time	3	71.18	3.04 *
Time x SW	72	23.42	

* p < .05
** p < .01

Post Hoc Scheffe Comparisons of Contrasts of Changes from Pretest to Posttest, Across Treatments

Contrast	F
2 vs. 1	.89
3 vs. 1	10.48*
4 vs. 1	4.34
2 vs. 3	3.61

* p < .05
** p < .01

TABLE 26

GRADE FIVE CTBS MATH TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	16.35	16.55
2.	Color-Light	15.07	17.79
3.	Light Only	19.26	19.94
4.	Color Only	19.67	22.67

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	188.74	2.84*
SW	73	66.38	
Time	1	91.66	20.38**
Treatment x Time	3	16.89	3.75*
Time x SW	73	4.50	

* $p < .05$
** $p < .01$

Post Hoc Scheffe Comparisons of Contrasts of Changes from Pretest to Posttest, Across Treatments

Contrast	F
2 vs. 1	5.79
4 vs. 1	6.53
2 vs. 3	4.45
1 vs. 2, 4	8.85*

* $p < .05$
** $p < .01$

TABLE 27

SUMMARY OF GRADE SIX ABILITY AND ACHIEVEMENT TEST RESULTS: TREATMENT OVER TIME

School #	Lorge - Thorndike Verbal I.Q.	Lorge - Thorndike Non-Verbal I.Q.	CTBS - Vocabularly	CTBS - Reading	CTBS - Math	
1 (Control)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	Conclusion: No support is evident that color/light combinations or light only or color only affects ability level or academic achievement.
2 (Color-Light)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	
3 (Light Only)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	
4 (Color Only)	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	No Significant Differences	

TABLE 28

GRADE SIX LORGE THORNDIKE, VERBAL TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	58.78	57.27
2.	Color-Light	62.86	59.50
3.	Light Only	59.89	55.37
4.	Color Only	60.35	58.82

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	114.71	0.44
SW	103	263.42	
Time	1	325.01	11.15 **
Treatment x Time	3	23.65	0.81
Time x SW	103	29.15	

* $p < .05$
** $p < .01$

TABLE 29

GRADE SIX LORGE THORNDIKE, NON-VERBAL TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	49.42	52.29
2.	Color-Light	56.86	56.93
3.	Light Only	53.94	53.94
4.	Color Only	61.71	62.00

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	943.06	2.96 *
SW	100	318.93	
Time	1	28.33	0.97
Treatment x Time	3	20.59	0.70
Time x SW	100	29.35	

* $p < .05$
** $p < .01$

TABLE 30

GRADE SIX CTBS VOCABULARY TEST RESULTS

Mean Scores

	School	Pretest	Posttest
1.	Control	23.49	25.60
2.	Color-Light	26.29	28.57
3.	Light Only	23.03	26.42
4.	Color Only	26.13	29.67

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	127.07	1.13
SW	95	112.22	
Time	1	327.97	20.08**
Treatment x Time	3	5.54	0.34
Time x SW	95	15.34	

* $p < .05$
** $p < .01$

TABLE 31

GRADE SIX CTBS READING TEST RESULTS

Mean Scores

	School	Prestest	Posttest
1.	Control	43.46	43.05
2.	Color-Light	49.00	43.71
3.	Light Only	42.55	37.49
4.	Color Only	49.07	45.93

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	462.85	1.61
SW	95	287.96	
Time	1	493.32	20.78**
Treatment x Time	3	52.29	2.20
Time x SW	95	23.74	

* $p < .05$
** $p < .01$

TABLE 32

GRADE SIX CTBS MATH TEST RESULTS

Mean Scores

	School	Prestest	Posttest
1.	Control	19.60	21.80
2.	Color-Light	20.40	20.53
3.	Light Only	18.70	19.91
4.	Color Only	25.53	26.33

Analysis of Variance

Source	D.F.	Mean Square	F
Treatment	3	362.78	5.14 **
SW	94	70.56	
Time	1	49.12	7.80 **
Treatment x Time	3	7.79	1.24
Time x SW	94	6.30	

* $p < .05$
** $p < .01$

Definitive cause-effect relationships between color/light, light only or color only treatments and ability levels or achievement of elementary students were not uncovered in this experiment. Patterns of significant relationships were highly inconsistent with the control school scoring significantly higher than the treatment schools in several cases. Consequently, the answer to question 1.1. is that generally, color or light have no effect on the ability or achievement levels of elementary students.

Question 1.2 - Attitudes Toward School Subjects

The School Subjects Attitude Scales (SSAS) developed by Nyberg and Clarke (1983) were used as one of the criterion measures for grades 5 and 6. The Scales measure three dimensions of attitude held by students about school subjects. Factor scores are provided for 1) evaluation (general feeling about the subject), 2) difficulty (perceived ease with which learning occurs) and 3) usefulness (pupils' perceptions about the utility of what is learned in the course).

The School Subjects Attitude Scales were administered during September as a pretest and during June as a posttest. Pupils in grades 5 and 6 recorded on mark-sense response sheets their responses concerning five school subject: Mathematics, French, Language (Reading), Science, and Social Studies. A composite score which represented students overall attitude toward the five subjects was computed for each of the evaluation, difficulty and usefulness factors.

Data analysis included calculation of means (averages) and standard deviations (an indicator of the spread or variability of scores) for each factor. The changes which occurred from September to June were computed and, for each group, these differences were tested for statistical significance (one-tailed t tests). Since the students responded anonymously no record was made of individual's responses. Accordingly, neither t tests to ascertain the statistical significance of differences between correlated means nor analysis of covariance to adjust for pretest score differences could be applied.

Tables 33, 34, and 35 portray the results obtained from the administration of the School Subjects Attitude Scales. Means and standard deviations for each of the three factors measured are displayed for the pretest administered in September and for the posttest in June. The changes in scores over the school year for each group are also tabulated.

A general decline in average scores for each aspect of attitude measured is expected over the period from September to June. An inspection of Tables 33, 34, and 35 indicates that the largest decrement for each of evaluation (general feeling about the subject), difficulty (perceptions concerning the ease with which learning occurs) and usefulness (the utility attributed to the five subjects) occurred for grade 6 in the control school. However, neither this change nor the pretest - posttest differences in any of the other schools reached statistical significance. The conclusion is that none of the experimental conditions had an effect on attitude toward school subjects for pupils enrolled in grades 5 and 6.

TABLE 33

OVERALL ATTITUDES TOWARD SCHOOL SUBJECTS

Experimental Conditions	School Subjects Attitude Scale Results: 5-Subject Evaluation Scale					
	Grade	N	Statistic[#]	Pretests	Posttests	Change
Control (no Color or light change)	5	25	$\bar{X}$	28.8	28.8	0.00
			SD	10.37	10.47	-0.10
	6	44	$\bar{X}$	27.7	24.6	-3.1
			SD	9.52	11.96	1.40
	5-6	69	$\bar{X}$	28.2	26.1	-2.1
			SD	9.89	11.61	1.72
Color and Light Change	5	17	$\bar{X}$	25.9	26.0	0.1
			SD	7.83	9.20	1.37
	6	16	$\bar{X}$	29.3	28.8	-0.5
			SD	9.43	7.21	-2.22
	5-6	33	$\bar{X}$	27.7	27.3	-0.4
			SD	8.85	8.39	-0.46
Light Change Only	5	38	$\bar{X}$	30.6	28.9	-1.7
			SD	7.56	9.84	2.28
	6	42	$\bar{X}$	28.2	28.4	0.2
			SD	9.81	9.77	-0.04
	5-6	80	$\bar{X}$	29.2	28.7	-0.5
			SD	8.97	9.79	0.82
Color Change Only	5	21	$\bar{X}$	31.6	31.8	0.2
			SD	8.33	8.95	0.62
	6	18	$\bar{X}$	29.4	28.7	-0.7
			SD	7.16	8.92	1.76
	5-6	39	$\bar{X}$	30.5	30.4	-0.1
			SD	7.83	9.04	1.21

[#] Note: $\bar{X}$ = mean or average.

SD = standard deviation; an index of the spread or variability of scores.

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TABLE 34

PUPILS' PERCEPTIONS OF USEFULNESS OF SCHOOL SUBJECTS

Experimental Conditions	School Subjects Attitude Scale Results: 5-Subject Usefulness Scale					
	Grade	N	Statistic[#]	Pretests	Posttests	Change
Control (no Color or light change)	5	25	$\bar{X}$	29.7	30.5	0.8
			SD	10.56	10.66	0.10
	6	44	$\bar{X}$	32.1	29.2	-2.9
			SD	8.72	12.3	3.58
	5-6	69	$\bar{X}$	31.1	29.6	-1.5
			SD	9.60	11.73	2.13
Color and Light Change	5	17	$\bar{X}$	28.7	27.2	-1.5
			SD	7.12	9.88	1.76
	6	16	$\bar{X}$	33.6	34.0	0.4
			SD	6.94	7.31	0.37
	5-6	33	$\bar{X}$	31.3	30.4	-0.9
			SD	7.42	9.34	1.08
Light Change Only	5	38	$\bar{X}$	33.2	31.8	-1.4
			SD	5.61	9.06	4.45
	6	42	$\bar{X}$	31.4	32.8	1.4
			SD	8.91	9.00	0.9
	5-6	80	$\bar{X}$	32.2	32.3	0.1
			SD	7.69	9.03	1.34
Color Change Only	5	21	$\bar{X}$	34.3	34.6	0.3
			SD	6.29	8.34	1.05
	6	18	$\bar{X}$	33.1	32.6	0.5
			SD	5.78	8.04	2.26
	5-6	39	$\bar{X}$	33.7	33.7	0.00
			SD	6.06	8.24	2.18

[#] Note: $\bar{X}$ = mean or average.

SD = standard deviation; an index of the spread or variability of scores.

TABLE 35

PUPILS' PERCEPTIONS OF DIFFICULTY OF SCHOOL SUBJECTS

Experimental Conditions	**School Subjects Attitude Scale Results: 5-Subject Difficulty Scale**					
	Grade	**N**	**Statistic**[#]	**Pretests**	**Posttests**	**Change**
Control (no Color or light change)	5	25	$\bar{X}$	27.4	26.3	-1.1
			SD	8.40	8.92	0.52
	6	44	$\bar{X}$	26.1	23.0	-3.1
			SD	7.95	9.34	1.39
	5-6	69	$\bar{X}$	26.6	24.2	-2.4
			SD	8.16	9.31	1.15
Color and Light Change	5	17	$\bar{X}$	24.2	25.0	0.8
			SD	6.52	8.20	1.68
	6	16	$\bar{X}$	27.7	27.3	-0.4
			SD	7.57	7.40	-0.17
	5-6	33	$\bar{X}$	26.1	26.2	0.1
			SD	7.29	7.88	0.59
Light Change Only	5	38	$\bar{X}$	28.3	27.1	-1.2
			SD	6.04	8.46	2.42
	6	42	$\bar{X}$	25.0	25.8	0.8
			SD	7.81	7.59	-0.22
	5-6	80	$\bar{X}$	26.5	26.4	-0.1
			SD	7.27	8.03	0.76
Color Change Only	5	21	$\bar{X}$	28.2	27.8	-0.4
			SD	7.92	7.59	-0.33
	6	18	$\bar{X}$	27.8	25.6	-2.2
			SD	6.26	7.45	1.19
	5-6	39	$\bar{X}$	28.0	26.7	-1.3
			SD	7.13	7.59	0.46

[#] Note: $\bar{X}$ = mean or average.

SD = standard deviation; an index of the spread or variability of scores.

Question 1.3 - Misbehaviors Warranting Disciplinary Action

Disciplinary problem documentation was designed in consultation with the principals of the four schools. Three categories of behavior problems were to be recorded:

1. Aggressive behavior - pushing, punching, hitting, scratching, biting, throwing, kicking, fighting, and shouting in class.

2. Destructive behavior - tearing, breaking and defacing.

3. Habitual disruptive behavior - talking, singing, whistling, tapping, and strolling.

Observations and recording days were rotated from Monday through Friday throughout the school year since it was assumed that behavior of the students at the beginning of the week or at the end of the week may be different from midweek behavior and therefore a more representative average would be obtained.

Frequencies of discipline problems were determined on a three point scale as follows:

1. Usually - behavior occurs 80 - 100% of the time.

2. Sometimes - behavior occurs 21 - 79% of the time.

3. Rarely - behavior occurs 1 - 20% of the time.

The ratings were based on the teacher's professional judgement. A copy of the data collection form appears on the next page as figure 5.

The highest aggression rate from Fall to Spring, reported in Table 36, was at the light only school with $\overline{X}=19.79$ and an increase from 14.0 in October to 28.875 in May. The lowest aggression rate was at the control school with $\overline{X}=1.5$ and a slight increase from 1.25 to 1.375. The color/light school has an $\overline{X}$ of 1.87 and a decrease from 3.375 to .875. The color only school had a mean of 2.0 and showed a decline from 4.125 to zero. No differences were significant for aggressive behavior over time between schools. However, the high range of measures from 28.875 to 0 suggest a need for more refined measures of aggressive behavior. A summary of the average rates obtained are presented in Table 36. ANOVA summaries are presented in Tables 37 through 39.

The highest mean ($\overline{X}=.66$) of destructive acts was at the color only school. The lowest incidence of destructive behavior ($\overline{X}=.16$) was at the control school. All schools demonstrated a decrease from October to May. No significant F ratios were obtained from schools over time. A significant F ratio for time was obtained suggesting the decline in overall destructive acts from Fall to Spring was statistically significant.

The highest mean of habitually disruptive acts was at the light only school with an $\overline{X}=61.5$ followed by the control school ($\overline{X}=35.9$). The lowest mean was at the color only school with $\overline{X}=26.4$. All schools except the light only school showed a decrease from October to May with the largest decrease at the color only school. However, the analysis of variance revealed no significant interactions effects (between schools over time) for habitually disruptive acts.

GRADE TWO — February

FIGURE 5 — Monday

Disciplinary Problem Recording Form

To be recorded once a week, at the end of each period - rotating days throughout the School Year.

Date	Aggressive Behavior	Destructive Behavior	Obvious Habitual Disruptive Behavior	Total
7			18	18
14			2	2
21			24	24
28			17	17
Total			61	61

Definitions

Aggressive Behaviour: (Physical or Verbal)
pushing, punching, hitting, scratching, biting, throwing, kicking, fighting, and shouting-in class

Destructive Behavior: tearing, breaking, and defacing

Obvious Habitual Disruptive Behavior: talking, singing, whistling, tapping, and strolling.

The total of all disciplinary incidents (aggression, destructiveness and habitual disruption) during the school year indicated the light only school with the highest rate of $\overline{X}=27.30$ followed by the control school with $\overline{X}=12.53$, the color/light school with $\overline{X}=11.22$ and the color only school with $\overline{X}=9.68$.

The analysis of variance revealed that a significant decline in destructive and habitually disruptive acts occurred overall from Fall to Spring. However, since the differences between schools is not significant no effect of color/light combinations or color or light on the behavior of elementary students can be stated.

TABLE 36

MEANS TABLES - INCIDENCE OF DISCIPLINE; COMPARISON BY SCHOOL

	Aggressive				Destructive				Habitually				Total Disciplinary Incidents
	Oct.	Feb.	May	Total	Oct.	Feb.	May	Total	Oct.	Feb.	May	Total	
School (Control)	1.25	1.875	1.375	1.5	0.250	.125	.125	.16	41.375	28.125	38.250	35.9	12.53
(Color/Light)	3.375	1.375	0.875	1.87	1.125	0.375	.0	.5	37.250	25.50	31.125	30.3	11.22
(Light Only)	14.0	16.5	28.80	19.79	0.875	0.250	0.750	.62	61.0	50.875	72.63	61.5	27.30
(Color Only)	4.125	1.875	0.0	2.0	1.750	.125	.125	.66	45.0	18.5	15.625	26.37	9.68
$\bar{X}$	5.69	5.41	7.78	6.29	1.0	.22	.25	.48	46.2	30.8	39.4	38.5	

TABLE 37

RESULTS FOR AGGRESSION: TREATMENT OVER TIME

Mean Scores

	School	Oct.	Feb.	May
1.	Control	1.25	1.88	1.38
2.	Color-Light	3.38	1.38	0.88
3.	Light Only	14.00	16.50	28.88
4.	Color Only	4.13	1.88	0.00

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	1945.08	1.22
SW	28	1599.40	
Time	2	53.87	0.48
Treatment x Time	6	167.55	1.49
Time x SW	56	112.26	

* $p < .05$

TABLE 38

RESULTS FOR DESTRUCTIVE BEHAVIOR: TREATMENT OVER TIME

	Treatment	Mean Scores		
	School	Oct.	Feb.	May
1.	Control	0.25	0.13	0.13
2.	Color-Light	1.13	0.38	0.00
3.	Light Only	0.88	0.25	0.75
4.	Color Only	1.75	0.13	0.13

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	1.23	0.52
SW	28	2.39	
Time	2	6.26	4.73 *
Treatment x Time	6	1.44	1.09
Time x SW	56	1.32	

* $p < .05$

TABLE 39

RESULTS FOR HABITUALLY DESRUPTIVE BEHAVIOR: TREATMENT OVER TIME

	Treatment	Mean Scores		
	School	Oct.	Nov.	Feb.
1.	Control	41.38	28.13	38.25
2.	Color-Light	37.25	25.50	31.13
3.	Light Only	61.00	50.88	72.63
4.	Color Only	45.00	18.50	15.63

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	5874.84	2.04
SW	28	2878.13	
Time	2	1908.52	3.84 *
Treatment x Time	6	599.03	1.21
Time x SW	56	497.21	

* $p < .05$

Question 1.4 - Absences due to illness

Two separate but related tests were undertaken within this study to assess the effects of full spectrum light on student absences. Question 1.4 addresses the effects of full-spectrum light without ultraviolet supplement on all student's absences due to illness in the three experimental schools and the control school. Question 5.0 addresses the question of ultraviolet light for grade 5 students at the light only school. Results for question 1.4 are reported here.

In the color/light and light only school "full-spectrum" Fluorescent tubes were added. The colors in the color/light and color only school were warm yellow and blue. The form used to record student absences is presented in Figure 6.

The percentage of yearly absence rates ranged from 3.7 to 6.1%. The control school and the color only school had the lowest annual percentage of absences at 3.7%, the color/light school had a annual absence rate of 4.2% and the light only school had the highest absence rate of 6.1%. These descriptive statistics are summarized in Table 40. The percentages of absence rates were subjected to t-tests for significance of difference between percentages for uncorrelated samples (Garrett, 1966:235). The results of the t-tests, summarized in Table 41, revealed that no significant differences were obtained between school absence rates. The conclusion is that neither color/light combinations nor light only nor color only had any significant effect on absence rates due to illness.

Question 1.5 - Refractive Eye Problems

Stereo vision tests and Instaline vision screening were carried out on students and staff of the four schools in this study in order to determine if color and/or light have any effect on eye function.

The Stereoscopic Vision Test is designed to test eye muscle balance. Stereoscopic vision deficiencies are not subject to variation over the short term, therefore, only posttests were performed. Tests for significance of difference on stereoscopic measures between schools revealed that no schools scored significantly differently on the Stereoscopic Vision Test.

The Instaline vision screening assessed visual acuity, which would be subject to variation over time. Pretests were administered in September, 1982 and posttests were administered in June, 1983 to students and staff in all four schools. Students who experienced increases or decreases in measures of visual acuity were placed in a group and average percentages of increase or decrease were computed for each school. All schools demonstrated greater decreases than increases in visual acuity for those students who experienced change in pre and posttest measures. The percentage of overall decrease is summarized in Table 42. The control school had the lowest decrease (9.65%) followed by the color/light school (10.6%) and the color only school (12.1%). The light only school had the highest decrease (21.7%), however, none of the percentages of decrease were found to be significant when t-tests for significance of difference between percentages for uncorrelated samples were applied. The conclusion is, therefore, that color/light combinations or light or color did not affect visual acuity of elementary students.

FIGURE 6

ABSENCES DUE TO ILLNESS

SCHOOL NORWOOD #2 SCHOOL YEAR 1982-83

Gr.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
1	18[1]	18	19	19	19	18	17	16	18	18	180
	11[2]	23.5	24	18	55	25.5	40	18.0	23.5	59	297.5
2	24	24	26	25	27	26	25	25	25	25	252
	20	17	18.5	14.5	45.5	16	33	12.5	14.5	23.5	215
3	19	18	18	18	20	20	21	21	21	20	196
	13.5	14	10	8.5	10	9	22.5	5.5	15.5	15.5	124
4	21	22	23	23	24	24	24	23	23	23	230
	4	7	25	17	19	9.5	19.5	6.5	9	13	129.5
5	19	19	19	19	19	20	19	19	19	19	191
	13.5	14.5	28	13	13	21	10	8.5	16	15.5	153
6	20	21	21	21	20	19	19	19	19	18	197
	8	13	25.5	37	5.5	16.5	13	7	31	10.5	167
ECS	26	25	24	24	25	25	24	24	24	23	244
	14.5	18.5	18.5	17.5	14.5	12.5	20.5	9.5	18.5	7.5	152
TOTAL	147	147	150	149	154	152	149	147	149	146	1490
	84.5	107.5	149.5	125.5	162.5	110	158.5	67.5	128	144.5	1238

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[1] Number of Students

[2] Number of Absences

TABLE 40

SUMMARY OF ABSENCE STATISTICS

	Enrollment	Total Days of Absence Grades K-6	Average Days of Absence per Student For School Year	Rank	Per Cent of Average Yearly Absence	Total Days of Attendance Possible
Control	304.2	2,187.5	7.19	1	3.7%	59,015
Color/Light	149	1,238	8.30	3	4.2%	28,906
Light Only	337	4,017.5	11.92	4	6.1%	65,378
Color Only	147.8	1,068	7.22	2	3.7%	28,673

TABLE 41

SIGNIFICANCE OF THE DIFFERENCE BETWEEN PERCENTAGES: PAIRWISE COMPARISONS OF STUDENT ABSENCES BETWEEN SCHOOLS

	Control	Color/Light	Light Only	Colour Only
Control	---	0.5	2.4	0.0
Color/Light		---	1.9	.5
Light Only			---	2.4
Color Only				---

Note: No values attain significance at the $p < .05$ level.

TABLE 42

RESULTS OF INSTALINE VISION TESTS

	N	PERCENTAGE CHANGE	RANK
Control	23	- 9.00%	1
Color Light	19	-10.6 %	2
Light Only	19	-21.79%	4
Color Only	20	-12.19%	3

Tests of significance of difference between percentages for uncorrelated samples reveal no significant differences between schools. Highest t-value obtained was 1.61.

Question 1.6 - Blood Pressure

All teachers and principals and a sample of ten students, randomly selected from one class at the grade two and four through six levels from each school, provided the data for the analysis of treatment effects on blood pressure levels. Morning and afternoon blood pressure readings were recorded a total of thirty-six times in the Fall, Winter and Spring of the 1982-83 school year, which totalled 6,120 distinct blood pressure measures. Analysis of variance was calculated on the systolic blood pressure measures, which were considered physiological indicators of emotional reactions.

Blood Pressure Results for Staff

No significant differences were discernable in tests across time for the staff of the four schools. Blood pressure of teachers in the color/light and color only school were expected to decrease because of the soothing effects of the color of the walls which the teachers faced during the day. The result of no significance may be due to the observation that teachers are mobile in the classroom and the blue walls it was anticipated teachers would face were largely ignored while the yellow walls the students faced stimulated the teachers as well.

Blood Pressure Results for Students

A summary of student blood pressure means for each school broken down by AM/PM and Fall, Winter and Spring appear in Table 43. A summary of Fall to Spring comparisons appear in Table 44. Fall, Winter and Spring results were each subjected to analysis of variance to determine if differences between schools over time (a.m. vs. p.m. and Fall to Spring) were significant. ANOVA results are summarized in Tables 45 through 49. Figures 7 - 10 graphically summarize a.m. and p.m. blood pressure results for students and teachers.

The results indicate that no significant differences between morning and afternoon levels were evident for the Fall or Spring measures. However, the light only school demonstrated a significant decrease in p.m. blood pressure compared to the other schools for the Winter measures. (Table 43).

Further analysis compared the percentage of change in the a.m. blood pressure measures in the Fall to the Spring, and the percentage of change in the p.m. blood pressure measures in the Fall to Spring (Table 44). This analysis revealed no significant differences for the a.m. measures, but the color/light school did demonstrate a significant increase in the p.m. blood pressure measures compared to the other schools.

The overall results of the analysis of variance tests reveal a rather sporadic relationship between the treatments and blood pressure. The two significant relationships were in opposite directions; showing a decrease from morning to afternoon for light only and an increase in afternoon levels from Fall to Spring for color/light. However, color does result in consistent, but non-significant, increases in a.m. to p.m. blood pressure suggesting that the stimulating effects of yellow in the color classrooms may have some short term effect on students. No clear effect can be observed between color/light combinations or color or light and students blood pressure. A recent study was conducted in Arkansas on the effects of color and light combinations on blood pressure levels and student achievement by Sydoriak (1984:71) who concluded that ". . . relaxing shades of blue, in particular robin's egg blue, significantly reduce systolic blood pressure." Further research into this question would be warranted using color environments that are completely soothing or completely stimulating, rather than combining color effects in an attempt to affect teachers differently than students. Combining of stimulating and soothing colours, as in the study reported here, did not permit the investigations of the separate effects of colour types.

TABLE 43

SUMMARY OF STUDENT BLOOD PRESSURE MEANS BY SCHOOL

TIME OF DAY AND TIME OF YEAR

		Fall (a)			Winter (b)			Spring (c)		
School	- N -	A.M.	P.M.	(A.M - P.M) Differences	A.M.	P.M.	(A.M. - P.M.) Differences	A.M.	P.M.	(A.M. - P.M.) Differences
Control	38	103.272	103.364	+.092	103.601	104.583	+.952	105.447	105.658	+.211
Color/Light	38	99.636	99.669	+.033	100.627	101.825	+1.198	102.833	104.579	+1.746
Light Only	39	101.380	100.803	-.577	101.936	101.000	-.936*	103.457	102.756	-.701
Color Only	38	102.382	103.360	+.978	102.807	103.601	+.794	104.053	105.140	+1.087

(a) No significant differences for Fall blood pressure readings.
(b) Light only school demonstrated a significant decrease in P.M. blood pressure compared to other schools in Winter.
(c) No significant differences in Spring blood pressure readings.

TABLE 60

SUMMARY OF STUDENT BLOOD PRESSURE MEANS BY SCHOOL
FALL - SPRING COMPARISONS

	N	Fall A.M.	Spring A.M.	(Fall - Spring)[a]	Fall P.M.	Spring P.M.	(Fall - Spring)[b]
Control	38	103.272	105.447	(+2.175)	103.364	105.658	(+2.294)
Color/Light	38	99.636	102.833	(+3.197)	99.669	106.579	(+6.910)*
Light Only	39	101.380	103.457	(+2.077)	100.803	102.756	(+1.953)
Color Only	38	102.382	104.053	(+1.671)	103.360	105.140	(+1.780)

(a) No significant differences between schools in A.M. Fall compared to A.M. Spring blood pressure readings.

(b) * Color/Light school demonstrated a significant increase in P.M. Fall to P.M. Spring blood pressure readings compared to other schools.

TABLE 45

RESULTS FOR STUDENT BLOOD PRESSURE - FALL TREATMENT OVER TIME OF DAY BETWEEN SCHOOLS

Mean Scores

	School	A. M.	P. M.
1.	Control	103.27	103.36
2.	Color-Light	99.64	99.67
3.	Light Only	101.38	100.80
4.	Color Only	102.38	103.36

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	217.52	2.26
SW	149	96.36	
Time	1	0.00	0.00
Treatment x Time	3	7.97	1.95
Time x SW	149	5.51	

* $p < .05$
** $p < .01$

TABLE 46

RESULTS FOR STUDENT BLOOD PRESSURE - WINTER TREATMENT OVER TIME OF DAY BETWEEN SCHOOLS

Mean Scores

	School	A. M.	P. M.
1.	Control	103.60	104.58
2.	Color-Light	100.63	101.83
3.	Light Only	101.94	101.00
4.	Color Only	102.81	103.60

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	145.81	1.69
SW	149	86.54	
Time	1	19.12	3.88
Treatment x Time	3	18.33	3.72 *
Time x SW	149	4.93	

* $p < .05$
** $p < .01$

Post-hoc Scheffe Comparisons of Contrasts of Changes From A. M. to P. M. Across Treatments

Contrast	F
1 vs 2	0.09
1 vs 3	7.19
1 vs 4	0.07
3 vs 1, 2, 4	10.96*

* $p < .05$
** $p < .01$

TABLE 47

RESULTS FOR STUDENT BLOOD PRESSURE - SPRING TREATMENT OVER TIME OF DAY BETWEEN SCHOOLS

Mean Scores

	School	A. M.	P. M.
1.	Control	105.45	105.66
2.	Color-Light	102.83	104.58
3.	Light Only	103.46	102.76
4.	Color Only	104.05	105.14

Anova Results

Source	D.F.	Mean Square	F
Treatment	3	86.85	0.99
SW	149	87.68	
Time	1	26.29	2.71
Treatment x Time	3	21.51	2.22
Time x SW	149	9.71	

* $p < .05$
** $p < .01$

TABLE 48

RESULTS FOR STUDENT BLOOD PRESSURE - PER CENT OF CHANGE IN A.M. MEASURES FALL TO SPRING: TREATMENT OVER TIME BETWEEN SCHOOLS

Mean % Change

	School	% Change
1.	Control	2.20
2.	Color-Light	3.28
3.	Light Only	2.16
4.	Color Only	1.73

Anova Results For % Change in A.M. Blood Pressure Fall to Spring

Source	D.F.	Mean Square	F
Treatment	3	16.50	1.05
SW	149	15.74	

* $p < .05$
** $p < .01$

TABLE 49

RESULTS FOR STUDENT BLOOD PRESSURE - PER CENT OF CHANGE IN P.M. MEASURES FALL TO SPRING: TREATMENT OVER TIME BETWEEN SCHOOLS

Mean % Change

School		% Change
1.	Control	2.32
2.	Color-Light	5.10
3.	Light Only	2.08
4.	Color Only	1.81

Anova Results for % Change in P. M. Blood Pressure Fall to Spring

Source	D.F.	Mean Square	F
Treatment	3	0.0089	4.26 **
SW	149	0.0021	

* p < .05
** p < .01

Mewman Keuls Procedure

Group 4			
Group 3			
Group 1			
Group 2	*	*	*

* Denotes pairs of groups significantly different at the .05 level.

FIGURE 7: MORNING SYSTOLIC BLOOD PRESSURE
WESTASKIWIN STUDENTS

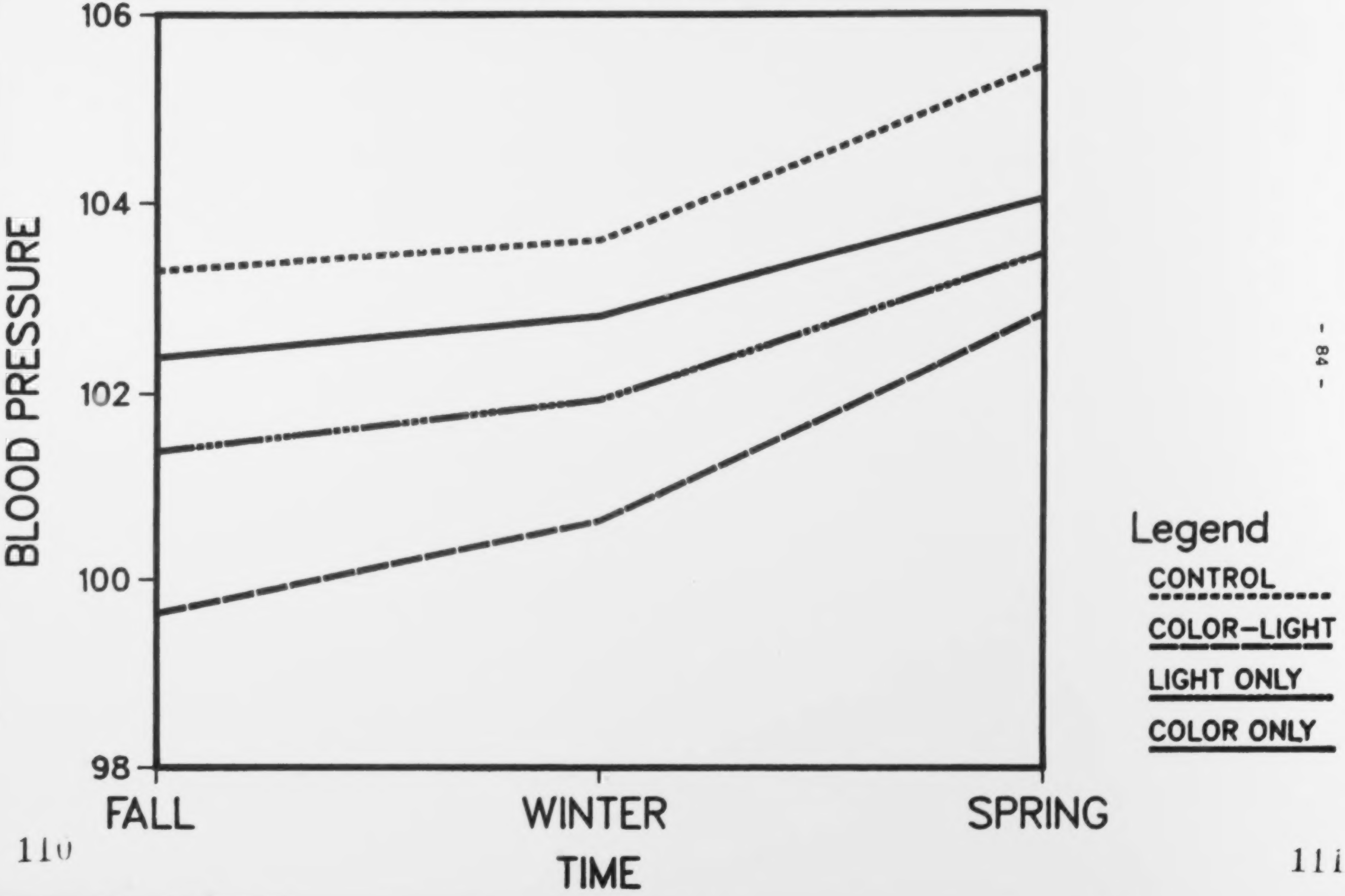


FIGURE 8: AFTERNOON SYSTOLIC BLOOD PRESSURE
WESTASKIWIN STUDENTS

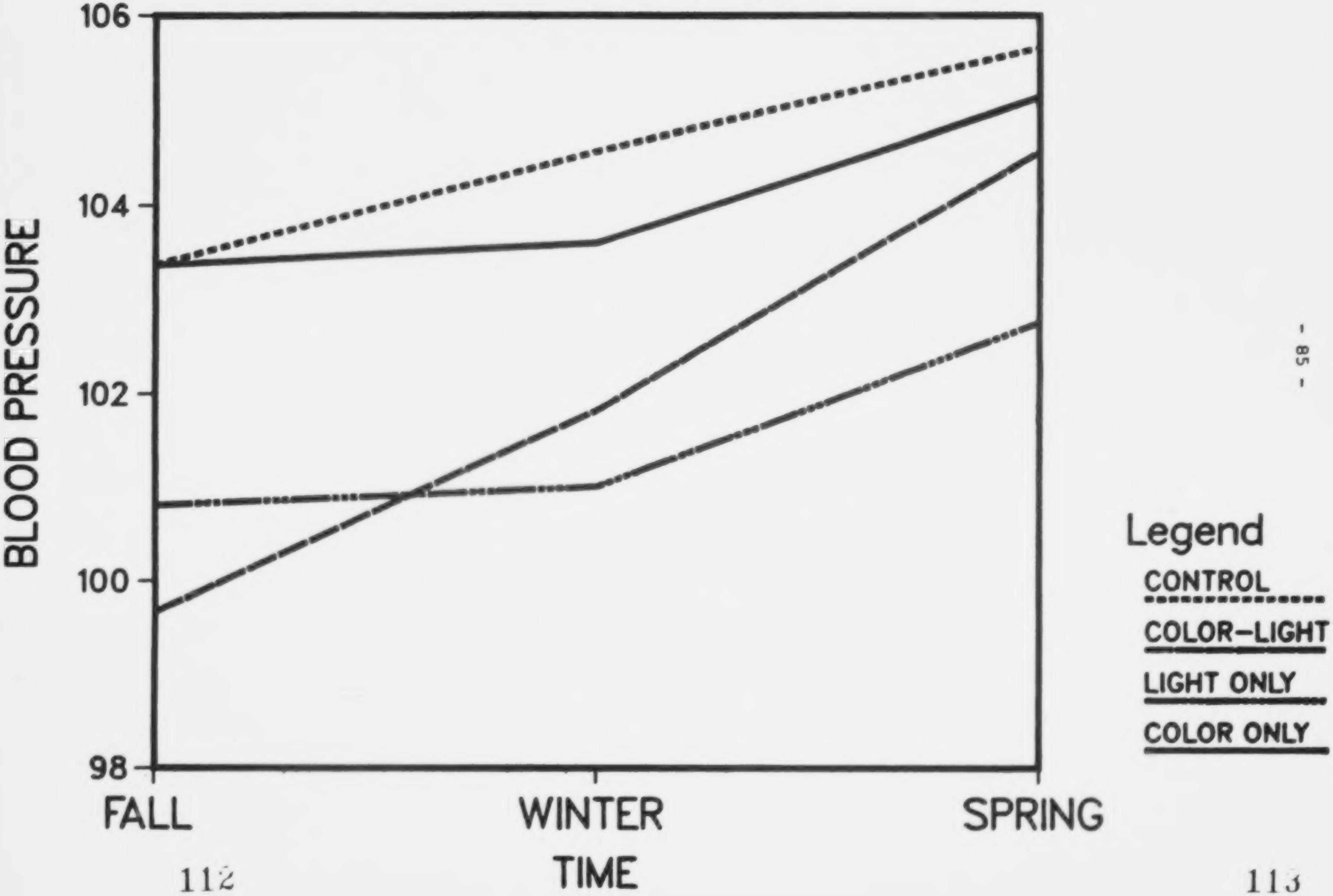


FIGURE 9: MORNING SYSTOLIC BLOOD PRESSURE
WESTASKIWIN TEACHERS

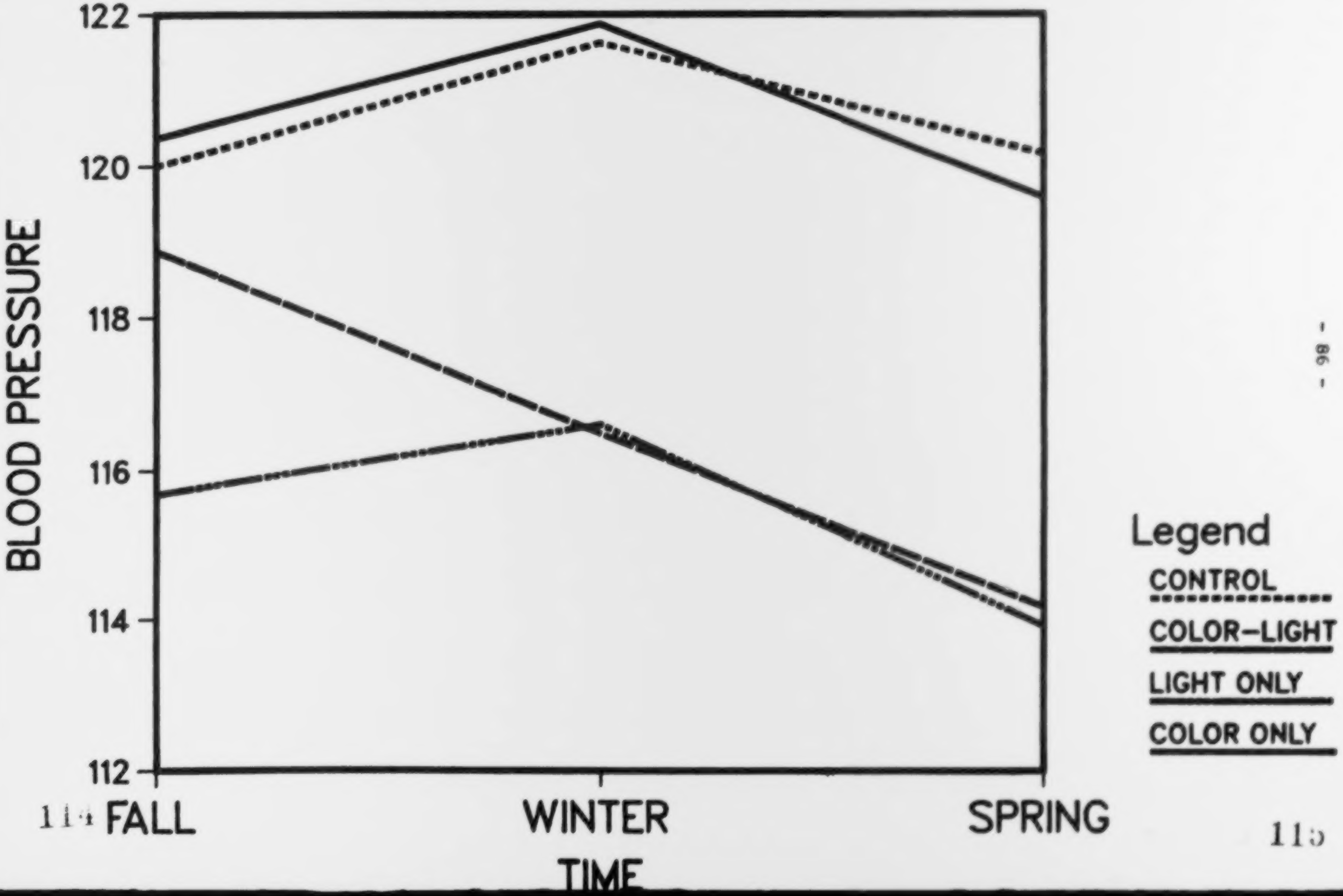
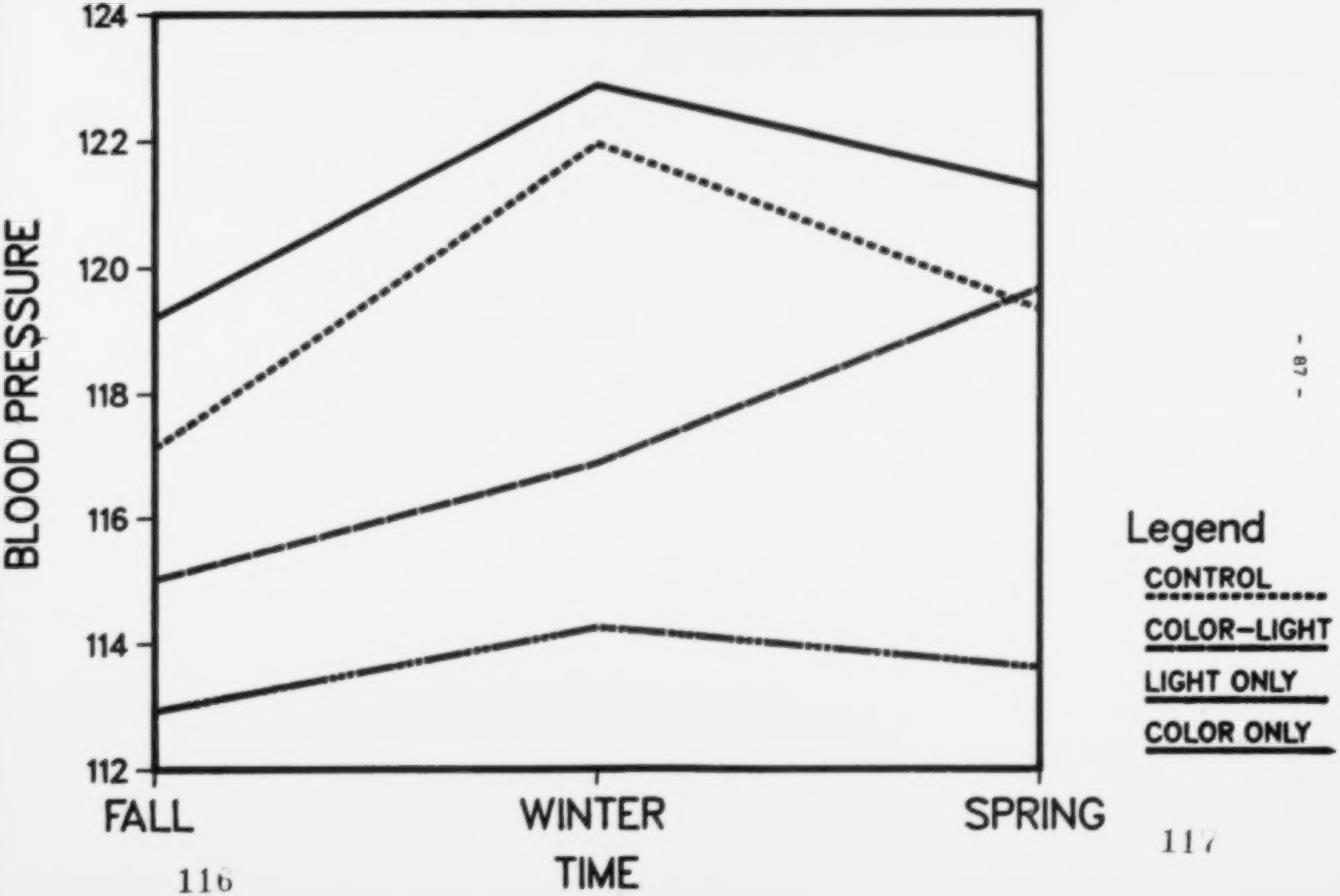


FIGURE 10: AFTERNOON SYSTOLIC BLOOD PRESSURE
WESTASKIWIN TEACHERS



Question 1.7 - Pre-adolescent Mood States

The answers to this research question are summarized here; a more complete report appears in Appendix B.

The mood measure employed in this study was the Pre-Adolescent Mood Scale (PAMS); a four dimensional measure based on data derived from several factor analytic investigations conducted in the Edmonton Public School District (Schokman-Gates, 1981, 1983). The four dimensions of PAMS are: Surgency; (cheerful, glad, joyful, like smiling, wonderful), Sadness; (lonely, sad, trapped, unwanted, upset), Aggression; (bad-tempered, bossy, furious, like hitting, mean), Mastery/Self-Esteem; (brave, handsome or pretty, powerful, strong, tough). Due to the possibility of "reactive effects", the actual instrument was intended to be as non-threatening and non-intrusive as possible, and was presented as an "activity" rather than a test.

Using a single-day repeated measure design, the PAMS instrument was presented to all 3rd through 6th grade children of the four schools first thing in the morning and again at the end of the school day. The students had been away from the school setting for several days, so any appreciable effects due to the color/light combinations should have been minimal or non-existent if color or light effects were short-term.

The principle condition of interest was the school effect (color, light and the color/light combinations on mood. Separate analyses on morning data revealed that pupils in the color/light, control and light only schools were significantly more Surgent than in the color only school, while no differences on Surgency among schools were noted for the afternoon or the combined data analyses.

Combined analyses did, however, reveal significant differences for Aggression with the light/color and control schools showing an increase over the light only and color only schools. This trend was also evident when the morning data were analyzed separately, nevertheless, since there were no significant differences found for Aggression in the afternoon data, the possibility exists that the individual school conditions experienced over the day may have had an equalizing effect on the students' aggressive feelings.

The mood factor of Mastery/Self-Esteem attained the greatest levels of significance, as well as the greatest number of differences among schools. The control and color only school were consistently lower in Mastery/Self-Esteem for the combined analyses, as well as on those for the morning and afternoon. Such robust findings suggest that the conditions present at the light/color and light only schools at the time of testing were significantly more conducive to the students' feelings of self-worth than were those conditions present at the control or color only schools. Multiple significance tests revealed that even though there were significances found between the control school and the color/light and light only schools, the greatest levels of differences were for these two experimental schools versus the color only school. The control school was actually more similar to the light only school than it was to the color only school on three of the four school analyses, with the color only school evincing the lowest scores on Mastery/Self-Esteem.

As can be seen from the amount of significant mood data produced by the four schools, there did appear to be mood-altering conditions present within these environments. Since this investigation was most interested in what, if any, differences may be found between the control and experimental schools, it was quite gratifying to discover significant results between schools on three of the mood scales, and on many of the individual items.

In general, students in the color/light and light only schools were found to have greater feelings of Surgency and Mastery/Self-Esteem, compared to those students in the control school. In addition, students in the color only school were significantly different from the control school only on the measures of Surgency over time, and the color only school had the lowest level of Mastery/Self-Esteem out of the four schools.

On the Aggression scale there were significant differences between the control school and two of the three experimental schools. The control school students scored significantly higher on Aggression than did those in the light only and color only schools. Surprisingly though, so did the children at the color/light school.

From the above data, it appears that the most robust and beneficial mood-altering environments were present at the color/light and light only schools. The one environmental factor which these two buildings had in common was the use of full-spectrum, as opposed to cool-white flourescent lighting. Nonetheless, since other physical and methodological characteristics were not controlled for, it would be improper to infer that lighting alone was responsible for the obtained mood results. The differences found between the control and color/light school which are controlled for physical characteristics permit stating only that the conditions present at the color/light school on the day mood data was collected were found to be significantly more conducive to increasing the students' positive mood states than were those conditions present at the control school. These findings suggest a need for further study of color/light combinations under both controlled and field conditions.

Question 2.0 - Electromagnetic Radiation Emissions Grade Three Behavior

Results for this research question are summarized here. A complete report appears in Appendix C.

The effects of eletromagnetic radiation emitted from fluorescent lights on the off-task behaviors of grade three students was studied by means of a quasi-experimental procedure. The independent variable was the level of electromagnetic radiation which was eliminated by grounding and shielding the fluorescent light fixtures in the experimental classroom. The pre-treatment and post-treatment off-task behaviors were recorded by a reliable on-site observer for two groups of grade three students.

The elimination of electromagnetic radiation resulted in a significant decrease in the rate of off-task behaviors for the heterogenous (with respect to hyperactivity) classroom group.

The elimination of electromagnetic radiation resulted in mixed and inconclusive findings for triad groups composed of the three students identified as being the most hyperactive. Contrary to expectations, triad groups demonstrated no benefit from the elimination of electromagnetic radiation.

The finding that classroom groups were affected by electromagnetic radiation shielding supports a call for further research into the electromagnetic radiation phenomenon.

Question 3.0 - Noise Levels in the Color/Light and Control Schools

Measuring Sound

Loudness of sound is measured in units called decibels. Sound measured with a sound level meter, however, is usually expressed as dBA. The "A" refers to the fact that the electrical signal produced by the microphone of the meter is passed through the A weighting network (a particular electrical circuit in the meter) in order to filter the signal and discriminate against certain frequencies. This network mimics our ears, which do not hear all frequencies equally well. Sound below 500 Hz is not heard as well as sound at intermediate or higher frequencies. Hence, sound measured on the A scale (dBA) is considered to be a reasonably accurate representation of our perception of sound.

Sound level meters have three other weighting networks - B, C, and D. Each filters the electrical signal differently, creating a different response curve, depending on the type of sound being measured. The differences are mainly in the sensitivity to low-frequency sounds. A is most biased against low frequencies and C is least biased. The C network is used to measure impact or impulse sound such as a rifle shot.

Sound level meters measure sound only at any particular moment. In order to obtain the general level of sound over time, however, many instantaneous measurements must be taken, averaged statistically, and expressed in relation to the period of interest. The following notations are used to express sound levels measured in dBA.

Leq - the equivalent sound level, or the average intensity of sound over a given period. Leq is the level of sound of the continuous sound which would have the same energy as the actual time-varying sound over the priod being considered. Technically, Leq is 10 times the logarithm of the time-averaged sound energy over a specified period. The number of hours during which sound is measured is often put in brackets. Leq(24) indicates energy averaged over 24 hours. Leq is the best simple measure used to predict the impact of intermittent noise of many different types. In Europe and Canada, measured community and industrial sound levels are commonly but not univerally expressed as dBA Leq. The Council endorses the use of this measure in Alberta.

L_{10} - the level of sound which is exceeded by instantaneous measured values only 10 percent of the time. L_{10} usually reflects peak sounds in the environment where measurements are being taken.

L_{50} - the level of sound exceeded 50 percent of the time. This is the median level of sound in the environment.

Sound Level Measurements

On September 21-23, 1983 sound level measurements were taken concurrently at the control and color/light schools. The sound level meters were operated between approximately 0830-1600 hours each day, at a sampling rate of 1/second (approximately 27,000 sound level measurements per day).

The sampling locations chosen were identical, with the sound level meters placed on suspended ceiling hangers (one ceiling tile removed) above the librarian's desk in the school library. The sound level meters were directed at the central library area.

Equipment Utilized

2 - Bruel & Kjaer Type 2225 Sound Level Meters
2 - Bruel & Kjaer C102 Data Storers

Measuring db(A) levels on fast response.

Environment

The study was carried out at the color/light school and at control school. Both schools are architectural "twins" and therefore identical, except for color and light.

Discussion of Results and Conclusions

Overall 85,530 data points (sound levels) were recorded in the color/light school and 80,010 data points were recorded in the control school. The difference is attributed to the sound level meters being left running for slightly longer time periods at the color/light school. The time discrepancy is not expected to significantly affect the data or conclusions.

Descriptive data between the two schools appear in table 50 which displays the cumulative frequencies of sound levels. Table 51 lists the L1, L10, L40, L50, L60, L90 and L99 values. Figure 10 graphically portrays these relationships. The background noise levels at the color/light school were in the range of 27-30 dBA with the majority of the noise levels associate with student activity in the range of 35-43 dBA. The control school on the other hand demonstrated no measured sound levels below 40 dBA and the majority of the noise levels associated with student activity were in the range of 42-49 dBA.

Table 52 illustrates the percentage of sound level distribution between the two schools. The products of per cent frequencies of sound level recordings at each decibel level were calculated, summed and divided by 100% to obtain the mean decibel level for each school. The mean dBA for the color light school was 39.34 and 45.51 for the control school. This compares to L50 (median scores) of 38.75 and 44.0 for the color/light and control schools respectively. The mean scores were subjected to a t-test for uncorrelated samples and an obtained t value of 7.545 was obtained. This value was significant at the .01 level supporting the conclusion that the color/light school was significantly quieter than the control school. The Color/Light School appeared to be consistently about 6 dBA quieter than the Control School. While the student enrollment at the Control School was higher (approximately 300 vs. 200 students), the library usage was expected to be similar and, therefore, enrollment difference is not likely to account for the noise level difference.

While the results of this comparison show significant difference in the sound levels between the two schools, a more comprehensive noise survey is warranted to study sound level differences for other student activities attributable to variations in treatments.

TABLE 30

CUMULATIVE DISTRIBUTION OF SOUND LEVELS

COMPARISON BETWEEN COLOR/LIGHT AND CONTROL SCHOOLS, WETASKIWIN

	Color/Light	Control
greater than 20 dBA	99.8%	99.9%
21	99.8%	99.9%
22	99.8%	99.9%
23	99.8%	99.9%
24	99.8%	99.9%
25	99.8%	99.9%
26	99.8%	99.9%
27	99.8%	99.9%
28	96.2%	99.9%
29	89.1%	99.9%
30	86.2%	99.9%
31	84.7%	99.9%
32	84.6%	99.9%
33	84.6%	99.9%
34	84.4%	99.9%
35	83.4%	99.9%
36	79.4%	99.9%
37	66.6%	99.9%
38	54.9%	99.9%
39	46.1%	99.9%
40	39.1%	99.9%
41	34.2%	99.9%
42	30.0%	98.7%
43	26.5%	66.7%
44	23.5%	48.8%
45	20.7%	39.9%
46	18.3%	33.2%
47	16.0%	28.1%
48	14.1%	23.8%
49	12.4%	20.1%
50	10.9%	16.9%
51	9.4%	13.8%
52	8.0%	11.3%
53	6.9%	9.3%
54	5.8%	7.5%
55	4.9%	6.1%
56	4.2%	4.9%
57	3.5%	3.9%
58	2.9%	3.1%
59	2.4%	2.4%
60	2.0%	1.9%
61	1.7%	1.4%
62	1.4%	1.0%
63	1.1%	0.7%
64	0.8%	0.5%
65	0.6%	0.3%
66	0.3%	0.2%
67	0.1%	0.1%
68	0.0%	0.0%
69	0.0%	0.0%

TABLE 51

COMPARISON BETWEEN MONITORED SOUND LEVELS AT COLOR/LIGHT AND CONTROL SCHOOLS, WETASKIWIN

	Color/Light	Control
L1	64.00 dBA	62.50 dBA
L10	50.75 dBA	52.75 dBA
L40	40.00 dBA	45.00 dBA
L50	38.75 dBA	44.00 dBA
L60	37.75 dBA	43.25 dBA
L90	29.00 dBA	42.50 dBA
L99	28.00 dBA	42.00 dBA

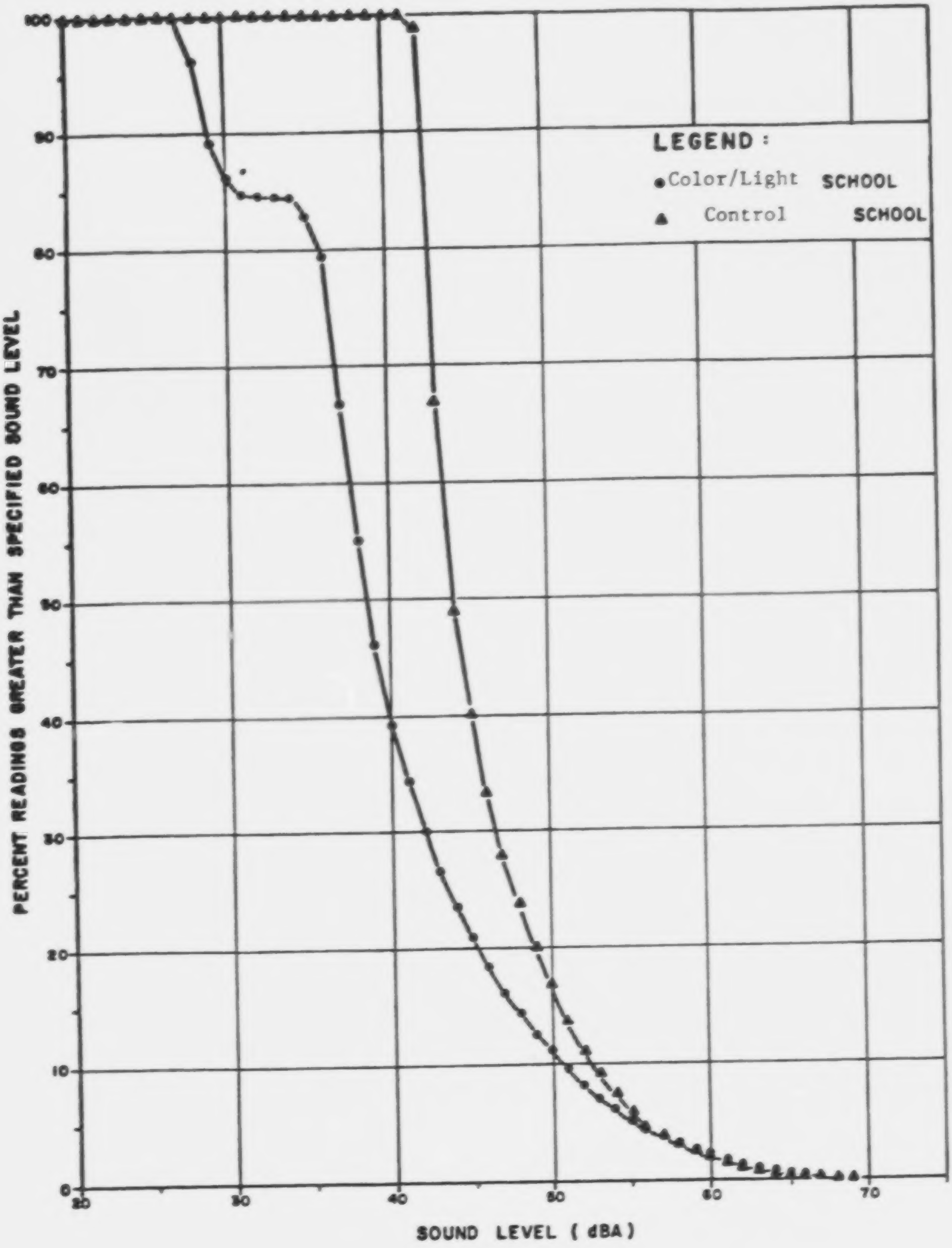


FIGURE 11

CUMULATIVE DISTRIBUTION OF SOUND LEVELS IN WETASKIWIN SCHOOLS.

TABLE 32

PERCENTAGE OF SOUND LEVEL DISTRIBUTION

	COLOR LIGHT		CONTROL SCHOOL	
Measures In dBA	Percent Frequency	ƒ.dBA	Percent Frequency	ƒ.dBa
20 - 21	0.0	0	0.0	0
22	0.0	0	0.0	0
23	0.0	0	0.0	0
24	0.0	0	0.0	0
25	0.0	0	0.0	0
26	0.0	0	0.0	0
27	0.0	0	0.0	0
28	3.5	98	0.0	0
29	7.1	205.9	0.0	0
30	2.8	84	0.0	0
31	1.5	46.5	0.0	0
32	0.0	0	0.0	0
33	0.0	0	0.0	0
34	0.2	6.8	0.0	0
35	0.9	31.5	0.0	0
36	3.9	140.4	0.0	0
37	12.8	473.6	0.0	0
38	11.6	440.8	0.0	0
39	8.8	343.2	0.0	0
40	7.0	280	0.0	0
41	4.8	196.8	0.0	0
42	4.2	176.4	1.2	50.4
43	3.4	146.2	31.9	1371.7
44	3.0	132	17.9	787.6
45	2.7	121.5	8.8	89.6
46	2.4	110.4	6.6	303.6
47	2.2	103.4	5.1	239.7
48	1.9	91.2	4.2	201.6
49	1.6	78.4	3.7	181.3
50	1.5	75	3.3	165
51	1.4	71.4	2.8	142.8
52	1.4	72.8	2.5	130
53	1.1	58.3	1.9	100.7
54	1.0	54	1.7	91.8
55	0.8	44	1.4	77
56	0.7	39.2	1.1	61.6
57	0.6	34.2	1.0	57
58	0.5	29	0.8	46.4
59	0.5	29.5	0.6	35.4
60	0.4	24	0.5	30
61	0.3	18.3	0.4	24.4
62	0.3	18.6	0.3	18.6
63	0.2	14.6	0.2	12.6
64	0.2	12.8	0.2	12.8
65	0.2	13	0.1	6.5
66	0.2	13.2	0.1	6.6
67	0.1	6.7	0.0	0
68	0.0	0	0.0	0
69	0.0	0	0.0	0
70	0.0	0	0.0	0
	97.7	3933.6	295.3	4551.1

$\bar{X}$ = 39.34 $\bar{X}$ = 45.51

SD = 10.76 SD = 22.65

Question 4.0 - Is there a relationship between the effects of enhanced ultraviolet light (simulated natural light) over ten months and the incidence of dental caries for grade 5 students?

The results of this research question is summarized here; the complete report is in press and will be available after the Summer of 1986.

Animal experimental work has suggested that ultraviolet radiation reduces incidence of dental caries. The opportunity to complete a study on children in the 1 ppm water fluoridated community of Wetaskiwin, Alberta Canada, through an experimental school design study became possible in 1982. In this northern community, like many other communities in North America and Europe, children have to travel to and from school between October and March during hours of darkness. Two classrooms at the four elementary schools in the city had full spectrum lighting with supplemental levels of ultraviolet radiation introduced and the children entering Grade 5 spent 22 months of study in the same classrooms. The full spectrum system simulates natural daylight specifically enhancing the mid and long range ultraviolet light: 280-400 nm. Full spectrum Vita-Lite fluorescent tubes were used with ultraviolet transmitting diffuser panels. A total of 102 children (all the Grade 5 children attending the schools) were involved in the study; 82% remaining for the total 22 months. Each child was examined three times during the investigation and DMFT, (Decayed, missing, filled teeth) DMFS, (decayed, missing, filled surfaces) gingivitis and oral hygiene indices were recorded. The DMFS examination included degrees of caries involvement:

Sound	no clinically detectable defect in the tooth surface.
Caries 1	minimal enamel defect, detected by a 'catch' with a sickle probe or a decalcification without enamel penetration.
Caries 2	marked involvement of enamel and/or dentine with detection by a 'sticking' sickle probe or obvious tooth loss from caries.
Caries 3	severe tooth loss from caries with probable pulpal death.

Results:

The dental caries increments (Tables 53 and 54) over the 22 month period showed a significant difference between those children who were in the classrooms with 'full spectrum' lighting compared with those children in the rooms with conventional lighting ($p < 0.001$). The children receiving 'full spectrum' light showed no increase in caries incidence when caries I is included and a small increase of 0.56 surfaces when caries I is excluded. The children in the rooms with conventional lighting showed an increase of more than 3 surfaces when caries I is included in the findings and 2.14 surfaces when caries I is excluded. Over the 22 month period, the caries I data for the treatment group went from DEFT (Decayed, filled teeth) 1.79 to 1.03 (decline 0.76) DEFS (Decayed, filled surfaces) 2.36 to 1.60 (decline 0.76). The caries I data for the control group over the 22 month period went from DEFT 1.07 to 183 (increase 0.76) DEFS 1.54 to 2.46 (increase 0.92). A decline in caries I teeth and surfaces is seen in the children receiving the ultraviolet light source and an increase in caries I teeth and surfaces is seen in the children receiving the conventional light source. The analysis of variance, utilizing the initial caries level as a covariant demonstrated a significant difference for the treatment or light source. (Tables 55 and 56). Both groups in the study showed a small improvement in oral hygiene and gingivitis measurements over the 22 month period (Tables 10 and 11).

TABLE 53

Caries Incidence With Standard Deviation Of Children In Ultraviolet Light Study Over 22 Months Including Caries I

		Treatment Group	Control Group
Base Line exam:	DEFT[a]	3.56 ± 2.27	2.56 ± 1.92
	DEFS[b]	5.03 ± 4.07	3.86 ± 3.35
22 months exam:	DEFT	3.43 ± 2.74	5.00 ± 2.97
	DEFS	4.83 ± 4.40	6.93 ± 4.41

a. Decayed, missing, filled teeth.
b. Decayed, missing, filled surfaces.

TABLE 54

Caries Incidence With Standard Deviation Of Children In Ultraviolet Light Study Over 22 Months Excluding Caries I Findings

		Treatment Group	Control Group
Base Line exam	DEFT	1.77 ± 1.91	1.49 ± 1.59
	DEFS	2.67 ± 3.41	2.32 ± 2.88
22 months exam	DEFT	2.40 ± 2.09	3.17 ± 2.34
	DEFS	3.23 ± 3.60	4.46 ± 3.84

TABLE 55

Analysis Of Variance For DEFT Utilizing Both Caries Indices

Source of Variation	Sum of Squares	DF	Mean Squares	F	Signif of F
COVARIATES	458.433	1	458.433	110.206	0.000
DEFT I	458.433	1	458.433	110.206	0.000
MAIN EFFECTS	107.123	3	35.708	8.584	0.000
Index	6.792	1	6.792	1.633	0.203
Agent	98.433	1	98.433	23.663	0.000*
Sex	1.335	1	1.335	0.321	0.572
2-WAY INTERACTIONS	19.132	3	6.377	1.533	0.208
Ind Agent	17.098	1	17.098	4.110	0.044
Ind Sex	1.210	1	1.210	0.291	0.591
Agent Sex	0.063	1	0.063	0.015	0.902
EXPLAINED	584.687	7	83.527	20.080	0.000
RESIDUAL	632.288	152	4.160		
TOTAL	1216.975	159	7.654		

* significant at 0.01 level

TABLE 56

Analysis Of Variance For DEFS Utilizing Both Caries Indices

Source of Variation	Sum of Squares	DF	Mean Squares	F	Signif of F
COVARIATES	1553.800	1	1553.800	195.946	0.000
DEFT I	1553.800	1	1553.800	195.946	0.000
MAIN EFFECTS	171.791	3	57.264	7.221	0.000
Index	9.731	1	9.731	1.227	0.270
Agent	160.829	1	160.829	20.282	0.000*
Sex	0.093	1	0.093	0.012	0.914
2-WAY INTERACTIONS	26.465	3	8.822	1.112	0.346
Ind Agent	20.504	1	20.504	2.586	0.110
Ind Sex	3.875	1	3.875	0.489	0.486
Agent Sex	0.657	1	0.657	0.083	0.774
EXPLAINED	1752.055	7	250.294	31.564	0.000
RESIDUAL	1205.320	152	7.930		
TOTAL	2957.375	159	18.600		

* significant at 0.01 level

TABLE 57

Oral Hygiene Index With Standard Deviation Of Children In Ultraviolet Light Study Over 22 Months

	Active Group	Control Group
Base Line OHI:	0.84 ± 0.37	1.02 ± 0.49
24 month OHI:	0.73 ± 0.41	0.82 ± 0.36

TABLE 58

Gingivitis Index With Standard Deviation Of Children In Ultraviolet Light Study Over 22 Months

	Active Group Mean/Standard Deviation	Control Group Mean/Standard Deviation
Base Line GI:	0.60 ± 0.35	0.74 ± 0.33
24 month GI:	0.49 ± 0.30	0.65 ± 0.57

Question 5.0 - Is there a relationship between the effect of supplemental ultraviolet light (simulated natural light) and absences due to illness of grade 5 students?

The independent variable in this research question was the exposure to supplemental levels of ultraviolet light which was transmitted to the grade five students by specially adapting light fixtures in the classroom with eggcrate style diffusers.

The Light only School had two grade five classes, one received supplemental ultraviolet light in the wave lengths of 280 - 400 Nanometers, the other class was without the ultraviolet supplement.

The absence figures for the school year reveal a marked difference. The class with supplemental ultraviolet experienced 138 absences for 20 students. The class without supplemental ultraviolet experienced 311 absences for 19 students. This data was subjected to a Z-score approximation to the Irwin-Fisher Exact Test. In this test, the number of students in each class were converted to the days of possible attendance for the school year:

20 students x 194 days = 3880 student days

19 students x 194 days = 3686 student days.

The number of absences was assumed to represent days absent. The two proportions were:

	Supplemental UV	Non-supplemental UV
Absenses	138	311
	----	----
Student Attendance Days	3880	3686

The calculated Z-score was 9.04 which is significant at the .0001 level of significance. This difference is highly significant and supports the conclusion that ultraviolet at a wavelength of 280 - 400 nanometers has a beneficial influence on the health of Grade five students over a school year. The research of M.A. Zamkova and E.I. Krivitskaya (1966) of the Pedagogical Institute, Leningrad, U.S.S.R. into "The effect of Irradiation by Ultraviolet Erythrine Lamps on the Working Ability of School Children" also noted a substantial improvement in working ability of their students.

The strong relationship between supplemental levels of ultraviolet light for one grade five class and the apparent health of the students is a very preliminary finding, however, when linked with earlier research conducted in the Soviet Union this finding supports a call for additional research into this question.

This chapter presented the results of the research. The following and last chapter will present a discussion of the findings, conclusions, recommendations and implications of the study.

CHAPTER 5

DISCUSSIONS, CONCLUSIONS, RECOMMENDATIONS, AND IMPLICATIONS

This study used a quasi-experimental, non-equivalent control group design to investigate the effects of color or light or color/light combinations as independent variables on a variety of student outcomes as the dependent variables. A pre-experimental, static-group comparison design was used for the investigation of mood and noise.

The rationale for the study emanated partially from changes to the physical environment of schools resulting from the energy conservation initiatives of the 1970's. Studies investigating the relationship between the physical environment of the school and student outcomes are relatively few and this study is considered a pioneer study of these phenomena in Alberta.

The findings for the specific research questions addressed in this study and results were as follows:

There were no consistently significant cause-effect relationships between a ten month effect of simulated outdoor light or perscribed colors or light/color combinations in the school environment and student ability or achievement levels, attitudes towards school subjects, misbehaviors warranting disciplinary action, absences due to illness, refractive eye problems or blood pressure.

Although no consistently significant relationships to blood pressure were found, there was some indication that color may have some short term effect on student blood pressure levels. Specifically, warm, stimulating colors were associated with increases in students' a.m. to p.m. blood pressure. Sydoriak (1984) in an Arkansas study, which employed appropriate controls for the effects of color, found that relaxing shades of blue significantly reduced systolic blood pressure.

All field based studies are subject to the confounding effects of extraneous variables, and this study is no exception. In the experimental schools where color was a treatment variable, the blending of cool and warm colors in the same room was a major fault in the design. It might be avoided in future studies to prevent the possible contradictions which occur when fields of vision overlap. The use of all warm, or all cool colors such as was done in the Arkansas study would eliminate this potential source of contamination.

Because of the strong effect found in this study between ultraviolet light and reduced dental caries and absences due to illness, ultraviolet light in the 280-400 nanometer range might be increased and used as an independent variable for some experimental classrooms exposed to full spectrum light in future studies.

Significant differences were observed between control and experimental schools in reference to treatment effects on pre adolescent mood levels. Students in the color/light and light only schools exhibited greater feelings of Surgency and Mastery/Self-Esteem, the color only school had the lowest levels of Mastery/Self-Esteem and the control and color/light school were highest on Aggression. These results are summarized below:

Control. . . . . . .Aggression+

Color/Light. . . . .Aggression+ Surgency+, Mastery/Self-Esteem+

Light Only . . . . .Surgency+ Mastery/Self-Esteem+

Color Only . . . . .Mastery/Self-Esteem-

The relationships suggest that the most robust and beneficial mood altering environments were present at the color/light and light only schools. Since other physical and methodological characteristics were not controlled for in this pre-experimental design, the conclusion that light caused more positive student moods is not stated. Rather, the findings support a call for further study of color and light as an independent variable affecting student performance variables.

Significant differences were also observed for the study of electromagnetic radiation emissions at the grade three level. Elimination of electromagnetic emissions from fluorescent lights resulted in a significant decrease in classroom off-task behaviors for classroom groups, but not for triad groups selected for hyperactivity.

The study of noise levels using a pre-experimental static group design between the architectually twinned control and color/light schools also revealed significant differences with the color/light school consistently 5-6 dBA quieter than the control school. The absence of pretest data for this research question, however, limits the generalizability of this finding, but supports a call for further research into this phenomenon.

Some experimental classes were exposed to supplemental levels of ultraviolet radiation in the 280-400 nanometer range. These classes were studied to assess the ultraviolet treatment variable on dental caries and absences due to illness for grade five students.

The findings with respect to dental caries was highly significant. The results showed that the students receiving the full spectrum light with ultraviolet supplement had very low or no increase in the incidence of dental caries over the 22 months period compared with the control group. DMFS findings, excluding caries I over the 22 months period, showed an increase from 2.67 to 3.23 (increase of 0.56) in the group receiving full spectrum light with ultraviolet supplement. This compared with an increase of 2.32 to 4.46 (increase of 2.14) in the control group ($p < 0.001$). In this study, the findings suggest that full spectrum lighting, which includes ultraviolet radiation simulating natural daylight, has a significant effect on the reduction of dental caries in children.

The findings regarding grade five absences were highly significant, with the grade five class exposed to supplemental ultraviolet experiencing significantly lower absences due to illness than the control grade five class in the same school. These findings are of profound practical significance and the experiment should be replicated in other settings.

A cost-benefit analysis was calculated to assess the cost of adapting light fixtures to ultraviolet radiation transmission capability compared to the dollar benefits of reduced dental caries and increased school attendance. In this study, the total installed cost of an adapted light fixture was $173.34 which included a standard fixture, an anodized aluminum reflector insert, an aluminum eggcrate diffuser, plus labor for installation. Full spectrum Vita-Lite fluorescent tubes cost $8.00 per tube minus the cost of a standard cool white tube of $0.78 for a net cost of $7.22 per tube. The School Buildings Branch of Alberta Education, advised that the average Alberta classroom contains 18 fluorescent light fixtures each containing two tubes for a total of 36 tubes per classroom. The total cost of converting the light fixtures to ultraviolet emission capability would be 18 x $173.34 + 36 x $7.22 = $3,380.04.

The dollar benefits of reduced dental caries were calculated on the basis of estimated costs of cavity repair as follows: type 1 - $40.00, type 2 or 3 - $105.00. The rate of reduced caries for the treatment group was obtained by calculating the difference in caries incidence between the treatment and control group; 1.68 for caries 1 and 1.58 for caries 2 or 3. The dollar benefits of increased attendance was calculated on the basis of estimated student cost per day ($21.42) provided by the Finance Branch of Alberta Education, and the difference in absence rates per student between the treatment and control groups. The rate of reduced caries was then multiplied by the cost of cavity repair and by the size of the class, n=20 and divided by 2 to obtain the annual dollar benefits. Differences in per student attendance rates between treatment and control classes were multiplied by per student daily cost and class size to obtain the annual dollar benefits for the treatment class. The total annual dollar benefits were $6,383.00. (20 x (1.68 x $40.00) + (1.58 x $105.00)) /2 + 20 (9.46 x $21.42) = $6,383.66.

The potential dollar benefits of reduced caries and increased attendance experienced by the treatment group of $6,383.66 minus the immediate cost of adapting light fixtures of $3,380.04 results in a net dollar benefit of $3,003.62. Dollar benefits in the second and subsequent years would be substantially higher, in the $6,000.00 range, as the cost of adapting fixtures would be a one time cost.

Relationships between color or light and student outcomes of mood and reduced noise levels were observed. The findings between ultraviolet radiation and reduced dental caries and absences due to illness were the most robust findings in this study. The evidence is not sufficient, however, to argue for changes to current school lighting or color schemes. Rather, when the overall results of the study are considered, the case for further research into the effects of ultraviolet light is strongly stated.

Implications for Further Research

This preliminary study into the effects of color and light in the physical environment of schools generated sufficient statistically significant results to support a call for further research. Some lessons were learned which can be translated into recommendations for future research designs. Specifically, future research into color or light effects should attempt to control more consistently for teacher variables such as the pupil control ideology and behavior of teachers. Outcome measures would likely best focus on student achievement, behavior, blood pressure, attendance and students' dental and general health. In addition, experimentation with ultraviolet supplements would be extremly useful in light of the findings in this study with supplemental ultraviolet and dental caries and grade five attendance. Further research would be profitably carried out both in the field and also under more controlled conditions in laboratory settings. In addition, research into optimal methods of providing ultraviolet light to a population needs to be addressed in future studies.

A tentative model for future environmental research which incorporates other lighting variables appears in Figure 12.

When schools are constructed today, interior design and lighting decisions must be made without the benefit of a research base to guide decisions in this area. This study was a preliminary attempt to build such a research base. Full spectrum light has been noted elsewhere to be of benefit for use in areas where color rendition is critical; such as the paint room in an auto body laboratory. Color may affect student behavior in specific program areas. Cool colors may be more beneficial for behaviorially disturbed special education students and warm colors may be desirable to stimulate learning disabled special education students. The hypothesis might be advanced that elementary schools and high schools should highlight stimulating warm colors and that junior high schools should highlight the more soothing cool colors for their clientele. Further research is needed to address these issues. Before specific recommendations can be made regarding light or color choices for schools a more extensive research base is required.

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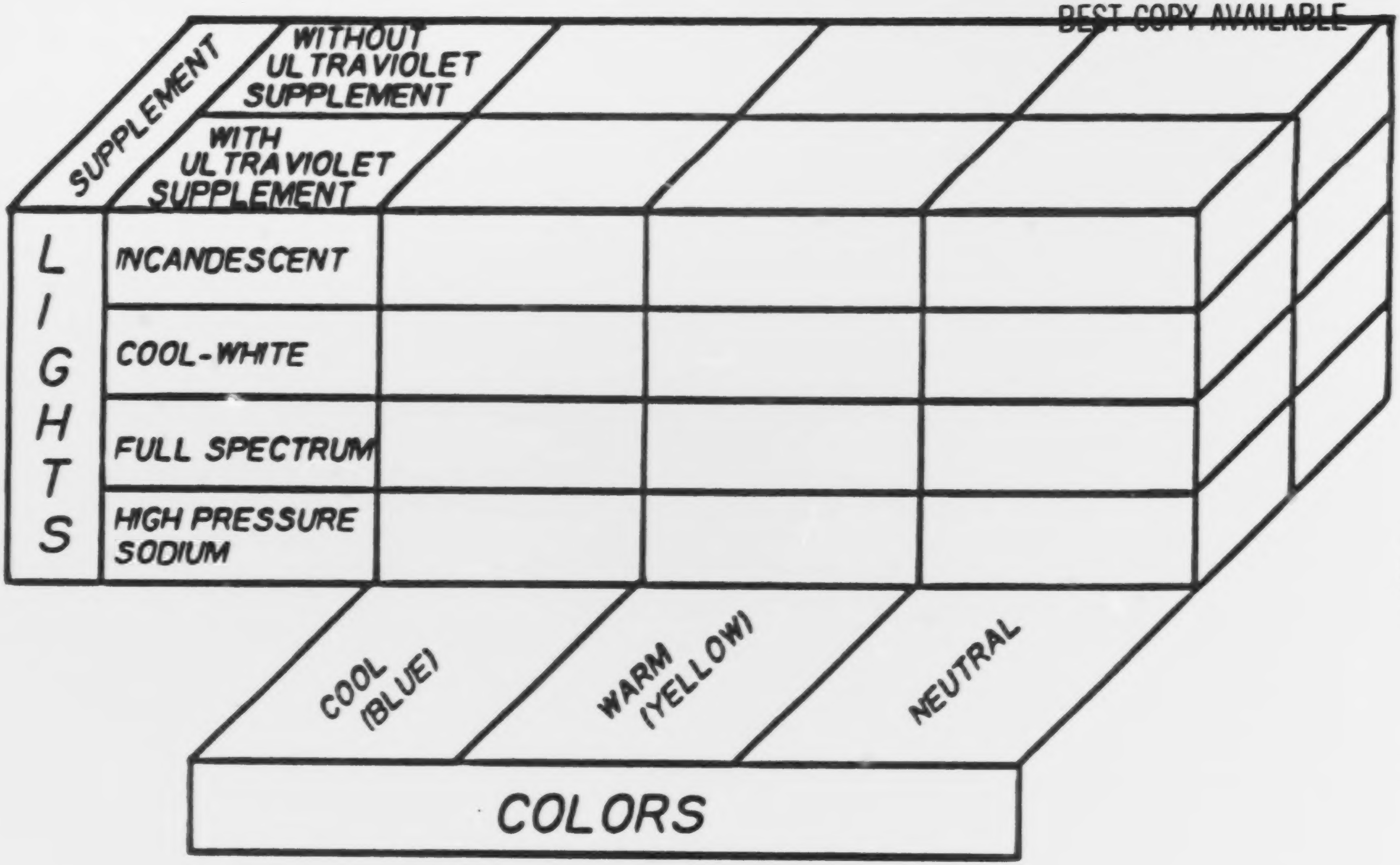
SUPPLEMENT
WITHOUT ULTRAVIOLET SUPPLEMENT
WITH ULTRAVIOLET SUPPLEMENT
LIGHTS
INCANDESCENT
COOL-WHITE
FULL SPECTRUM
HIGH PRESSURE SODIUM
COOL (BLUE)
WARM (YELLOW)
NEUTRAL
COLORS

CONTROL FOR
- STUDENT VARIABLES
- TEACHER VARIABLES

MEASURE FOR
- ACHIEVEMENT
- BEHAVIOR
- BLOOD PRESSURE
- ATTENDANCE

Figure 12 **A model for future environmental research.**

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APPENDICES

A - School Subjects Attitude Scale Tests 115

B - Pre-Adolescent Mood Variation Study 117

C - Electromagnetic Radiation and Student Off-Task Behavior Study 126

D - Dental Study In Press 166

E - Measurement of Ultraviolet Light From Fluorescent Lighting in Wetaskiwin Schools - 15 September, 1982 167

F - Illuminance Survey - Schools of the Wetaskiwin School District No. 264 171

APPENDIX A

School Subjects Attitude Scale Tests

The School Subjects Attitude Scales (SSAS) was constructed, validated and normed for use in Alberta during a period extending from 1978 to 1983. The instrument, intended primarily for use in research, measures students' attitudes towards school subjects.

It is of the semantic differential-type consisting of twenty-four sets of bipolar words, such as unpleasant-pleasant, useless-useful, etc. There are five response positions between each of the words in the pair.

Factor analysis of student responses revealed three clearly different scores: evaluative, usefulness, and difficulty. The SSAS thus produces three scores, each based on eight items.

Construct validity of the instrument was investigted by comparing scores for logically different groups. Four comparisons yielded results that agreed with anticipated results. For example, it was hypothesized that males would be more positively disposed to science on all three scales as compared to females, and this was found to be the case. Also, the patterns of scores agreed with the preferences stated by students; that is, school subjects identified as liked, disliked, hard, easy, useful, and useless received scores that reflected these opinions.

The norms developed were based on score means of classes as opposed to scores of individual students. Classes of ten students, or more, only, were included in the norming sample, that involved 137 schools. Norms for 97 school subjects in grades 5 to 12 were produced. As might be expected, reliability estimates of scores for classes were high. Alpha coefficients for a convenient sample of sixteen school subjects ranged from .97 to .99 for the evaluative scale, .92 to .99 for the usefulness scale, and .82 to .93 for the difficulty scale.

The SSAS, although a comparatively new measuring instrument, has already been used successfully in a number of studies. It is distributed by the School Book Branch of Alberta Education.

NCS Trans Optic M808 325151 321

Alberta
EDUCATION

SCHOOL SUBJECTS ATTITUDE SCALES

ALBERTA EDUCATION 1982

FOR INSTRUCTIONS, SEE OTHER SIDE

AGE YEARS		SCHOOL CODE			
☐	☐	☐	☐	☐	☐
⓪	⓪	⓪	⓪	⓪	⓪
①	①	①	①	①	①
②	②	②	②	②	②
③	③	③	③	③	③
④	④	④	④	④	④
⑤	⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨	⑨	⑨

SEX

FEMALE ○

MALE ○

GRADE	
⑤	⑨
⑥	⑩
⑦	⑪
⑧	⑫

ELEMENTARY OR JR. HIGH SUBJECT

Language Arts
- ○ Reading (Literature)
- ○ Language (Composition)
- ○ Spelling

- ○ Art
- ○ Drama
- ○ French
- ○ Guidance 9
- ○ Health
- ○ A. ____________________
- ○ B. ____________________
- ○ Home Economics
- ○ Industrial Arts
- ○ Mathematics
- ○ Music
- ○ Physical Education
- ○ Science
- ○ Social Studies
- ○ Typing
- ○ C. ____________________
- ○ D. ____________________
- ○ E. ____________________

SPCL. CODES			SR. HIGH COURSE			
☐	☐	☐	☐	☐	☐	☐
⓪	⓪	⓪	⓪	⓪	⓪	⓪
①	①	①	①	①	①	①
②	②	②	②	②	②	②
③	③	③	③	③	③	③
④	④	④	④	④	④	④
⑤	⑤	⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨	⑨	⑨	⑨

SUBJECT ____________________

SCHOOL ____________________

Place only one mark between each pair of words.
Complete ALL of the pairs.

	very much	a bit	neither	a bit	very much	
nice	○	○	○	○	○	awful
boring	○	○	○	○	○	interesting
unpleasant	○	○	○	○	○	pleasant
dislike	○	○	○	○	○	like
bright	○	○	○	○	○	dull
dead	○	○	○	○	○	alive
lively	○	○	○	○	○	listless (inactive, lazy)
exciting	○	○	○	○	○	tiresome (makes a person feel tired)
useless	○	○	○	○	○	useful
important	○	○	○	○	○	unimportant
impractical	○	○	○	○	○	practical (useful or workable)
worthless	○	○	○	○	○	valuable
helpful	○	○	○	○	○	unhelpful
unnecessary	○	○	○	○	○	necessary
harmful	○	○	○	○	○	advantageous (brings good or gain)
meaningful	○	○	○	○	○	meaningless
hard	○	○	○	○	○	easy
light	○	○	○	○	○	heavy (a lot of work)
clear	○	○	○	○	○	confusing (mixes a person up)
complicated	○	○	○	○	○	simple
elementary	○	○	○	○	○	advanced (beyond the beginning level)
strange	○	○	○	○	○	familiar
understandable	○	○	○	○	○	puzzling (hard to understand)
undemanding	○	○	○	○	○	rigorous (has to be exactly right)

Developed by N.R. Nyberg and S.C.T. Clarke,
University of Alberta, Edmonton, Canada

Printed in U.S.A.

IMPORTANT DIRECTIONS FOR MARKING ANSWERS

- Use HB pencil only.
- Make heavy black marks filling circle completely. The letter or number inside must not be visible.
- Erase cleanly any answer you wish to change.
- Make no stray marks on this answer sheet.

INSTRUCTIONS

1. Indicate your age, school code, sex and grade by darkening the proper responses in each box.

   If you are in elementary or junior high school, indicate which subject you are rating by darkening the corresponding bubble.

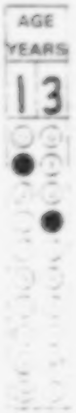
   If you are in senior high school, fill in the code of the course you are rating, and darken the corresponding bubbles in the course grid.

   Print the name of the subject or course you are rating and the name of your school.

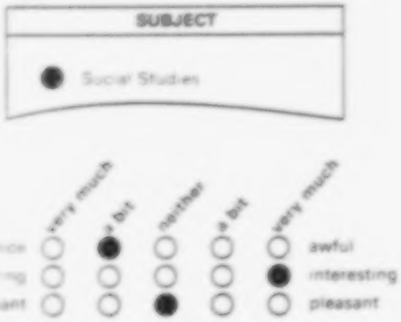
   Do not place your name on the answer sheet. Your opinions are to remain confidential.

2. For each pair of words, rate the school subject. Please work quickly. It is better to give your first feelings rather than to think hard about each pair of words. If you do not know the meaning of some of the words, please ask.

EXAMPLES



Correctly filled out AGE grid for 13 year old student.



The student thought Social Studies was a bit nice, very much interesting, and neither pleasant nor unpleasant.

APPENDIX B

Question 1.7 - Pre-Adolescent Mood States

Mood data were collected on 384 third through sixth grade students in each of the four participating Wetaskiwin schools on May 29, 1983. One grade three class was excluded in the May assessment. Consequently, 98 grade three students were subsequently assessed on the mood scales on June 11, 1983.

The mood measure employed in this study was the Pre-Adolescent Mood Scale (PAMS); a four dimensional measure based on data derived from several factor analytic investigations conducted in the Edmonton Public School District (SchoKman-Gates, 1981, 1983). The four dimensions of PAMS are: Surgency; (cheerful, glad, joyful, like smiling, wonderful), Sadness; (lonely, sad, trapped, unwanted, upset), Aggression; (bad-tempered, bossy, fuirous, like hitting, mean), Mastery/Self-Esteem; (brave, handsome or pretty, powerful, strong, tough). As the following sample instrument illustrates, the PAMS instrument is comprised of 20 items or mood markers (five per dimension), each arranged in the centre of a box which was headed by the phrase, "Right now I feel . . ." Four varying-sized circles representing the response format for the measure surrounded each item. The instructions and example printed on the measure indicated that the child was to draw a line from the mood item to the size of the circle which best described how they felt at that moment. The circles graduated in size from the smallest, equalling a response of "not at all" (score of zero), through two intermediate forms "a little" and "somewhat" and then onto the largest size, which represented the response "a lot" (score of three). Due to the possibility of "reactive effects", the actual instrument was intended to be as non-threatening and non-intrusive as possible, and was presented as an "activity" rather than a test.

Ideally, measurements using PAMS would have been taken at the commencement of this project, and then periodically and at different school hours throughout the year, however because the study had begun before the Pre-adolescent mood component was envisaged, a different research design became necessary.

Using a single-day repeated measure design, the PAMS instrument was presented to all 3rd through 6th grade children of the four schools first thing in the morning and again at the end of the school day. A Monday was selected as the most appropriate day for administration of the PAMS since this day was most typical i.e. devoid of special assemblies, field trips, etc. and it was the day the students returned after being away from the school environment for two days. The first consideration was important for reducing the effects of confounding variables and the second was important for isolating the short term effects of color or light on student mood states.

If color and/or light do have lasting physiological or psychological effects, then the eight-month exposure to the modified environments which the students had already experienced should have been clearly found in differences between mood levels of the three experimental groups and the control group, assuming other confounding variables were not operating. There are no consistent data in the literature on how long physiological effects last, or even if they do carry over from day to day. Is it the continuing influence of the color or light wavelengths which alter the physiological reactions and thereby the behavior and mood of the individual, or does one readily habituate to these environmental conditions (as purported by Faber Birren cited in

Johnson, 1983)? No one has yet adequately answered this question and thus the need for a Monday as the experimental day to measure the student's moods. The students had been away from the school setting for several days, so any appreciable effects due to the color/light combinations should have been minimal or non-existant if color or light effects were short-term.

The principal condition of interest was the school effect on mood, therefore, the main data regarding this will be th eonly data presented. Additionally, in order to be as succinct as possible with the presentation of significant data, tables 54 through 56 present summaries of the morning and afternoon means, the combined morning and afternoon means, and significant differences associated with means.

Separate analyses on morning data revealed that the color/light, control and light only schools were significantly more Surgent than the color only school, while no differences on Surgency among schools were noted for the afternoon or the combined data analyses.

Combined analyses did, however, reveal significant differences for Aggression with the light/color and control schools showing an increase over the light only and color only schools. This trend was also evident when the morning data were analyzed separately, nevertheless, since there were no significant differences found for Aggression in the afternoon data, the possibility exists that the individual school conditions experienced over the day may have had an equalizing effect on the students' aggressive feelings. Item analyses of the Aggression dimension revealed differences on all five of its items, with the light/color and control schools having the greatest impact on this mood dimension. These two schools were significantly higher than the light only and color only schools on overall feelings of being bad tempered, bossy and mean, as well as feeling more like hitting.

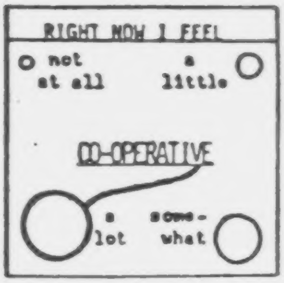
The mood factor of Mastery/Self-Esteem attained the greatest levels of significance, as well as the greatest number of differences among schools. The control and color only school were consistently lower in Mastery/Self-Esteem for the combined analyses, as well as on those for the morning and afternoon. Such robust findings suggest that the conditions present at the light/color and light only schools at the time of testing were significantly more conducive to the students' feelings of self-worth than were those conditions present at the control or color only schools. Multiple significance tests revealed that even though there were significances found between the control school and the color/light and light only schools, the greatest levels of difference were for these two experimental schools versus the color only school. The control school was actually more similar to the light only school than it ws to the color only school on three of the four school analyses, with the color only school envincing the lowest scores on Mastery/Self-Esteem. Item analyses of the Mastery/Self-Esteem dimension revealed that the students of the light/color and light only schools felt significantly more brave, handsome or pretty and strong in general than did those students at the control and color only school. Mood item tough revealed its greatest differences to be between the color/light and color only schools. On all items except handsome or pretty the color only school had the lowest level of Master/Self-Esteem followed by the control school, light only and finally the color/light school with the highest degree of such positive feelings. The handsome or pretty item showed a shift in the relative school ordering, with the control school students feeling less confident about their attractiveness than did those in the three experimental schools.

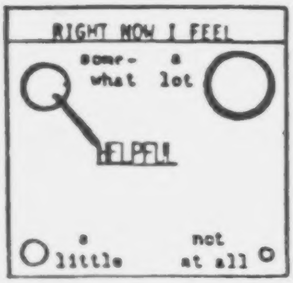
RIGHT NOW I FEEL

(PAMS)

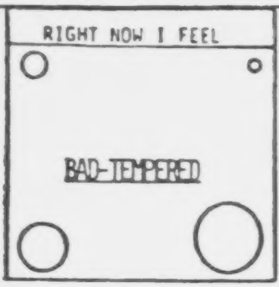
INSTRUCTIONS: Here are some statements which are often used to describe feelings. Please read each statement carefully, and show how you feel by drawing a line from the centre word to the size of circle which best describes how you feel right now.

EXAMPLES:

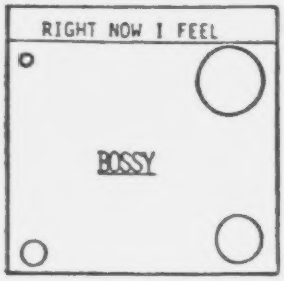

RIGHT NOW I FEEL
not at all
a little
CO-OPERATIVE
a lot
some-what


RIGHT NOW I FEEL
some-what
a lot
HELPFUL
a little
not at all

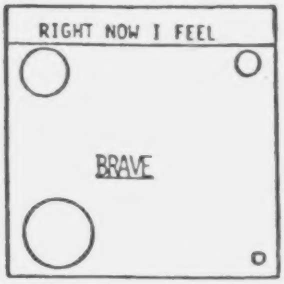
1.


RIGHT NOW I FEEL
BAD-TEMPERED

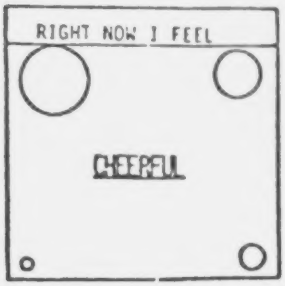
2.


RIGHT NOW I FEEL
BOSSY

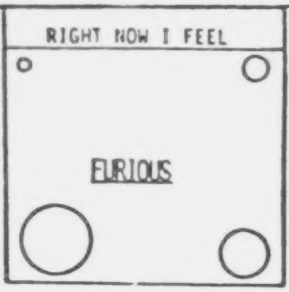
3.


RIGHT NOW I FEEL
BRAVE

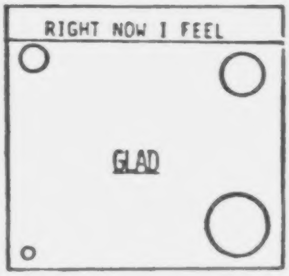
4.


RIGHT NOW I FEEL
CHEERFUL

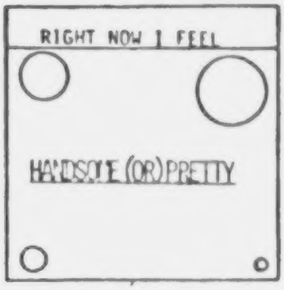
5.


RIGHT NOW I FEEL
FURIOUS

6.


RIGHT NOW I FEEL
GLAD

7.


RIGHT NOW I FEEL
HANDSOME (OR) PRETTY

8.

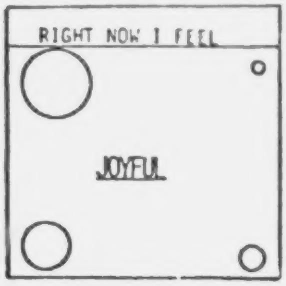
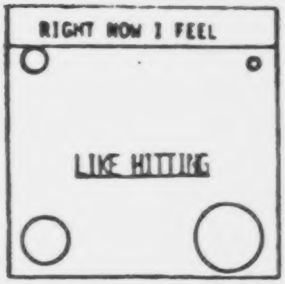

RIGHT NOW I FEEL
JOYFUL

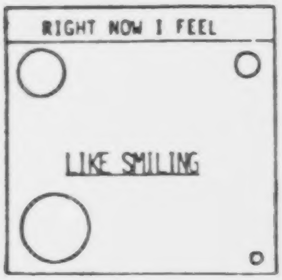
FIGURE 12 - Pre-Adolescent Mood Scale

please turn over....

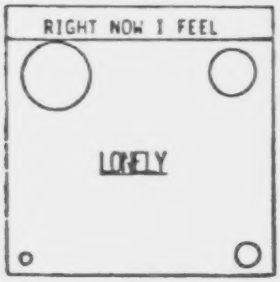
9.


RIGHT NOW I FEEL
LIKE HITTING

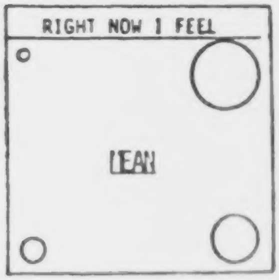
10.


RIGHT NOW I FEEL
LIKE SMILING

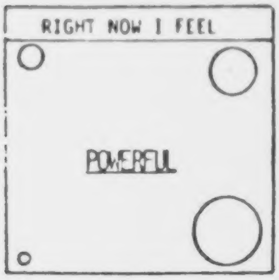
11.


RIGHT NOW I FEEL
LONELY

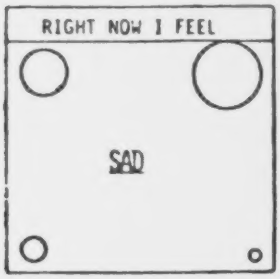
12.


RIGHT NOW I FEEL
MEAN

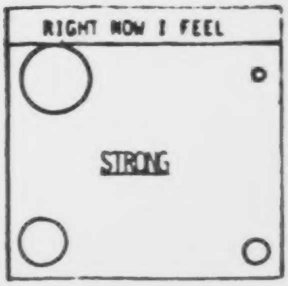
13.


RIGHT NOW I FEEL
POWERFUL

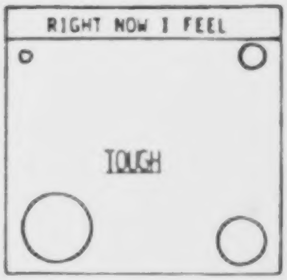
14.


RIGHT NOW I FEEL
SAD

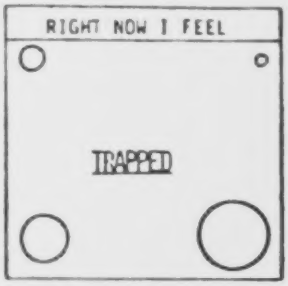
15.


RIGHT NOW I FEEL
STRONG

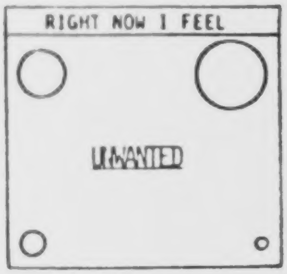
16.


RIGHT NOW I FEEL
TOUGH

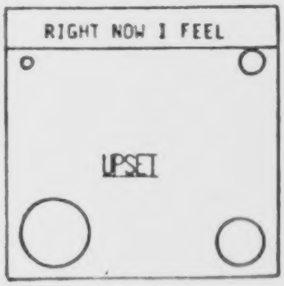
17.


RIGHT NOW I FEEL
TRAPPED

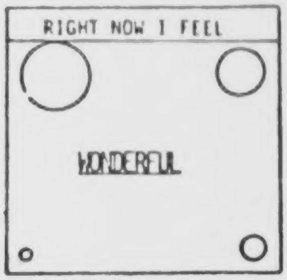
18.


RIGHT NOW I FEEL
UNWANTED

19.


RIGHT NOW I FEEL
UPSET

20.


RIGHT NOW I FEEL
WONDERFUL

PAMS SCORING SHEET

Name:
Age:
Grade:

	Item #	Scale: SURGENCY	SADNESS	AGGRESSION	MASTERY/SELF-ESTEEM
od-tempered	1.			☐	
ossy	2.			☐	
rave	3.				☐
heerful	4.	☐			
urious	5.			☐	
lad	6.	☐			
andsome (or) Pretty	7.				☐
oyl	8.	☐			
ike Hitting	9.			☐	
Smiling	10.	☐			
onely	11.		☐		
ean	12.			☐	
owerful	13.				☐
ad	14.		☐		
trong	15.				☐
Tough	16.				☐
Trapped	17.		☐		
nwanted	18.		☐		
pset	19.		☐		
Wonderful	20.	☐			
		TOTAL: S	SD	A	SM

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All of the experimental schools experienced an increase in Surgency over the school day, while the control school demonstrated a reverse pattern, with an actual decrease in Surgent feelings. A breakdown of the Surgency mood scales into their component parts indicated that the significances among the experimental and control schools were mainly attributable to the fact that the students from the experimental schools appeared significantly more cheerful and glad in the afternoon, and felt more like smiling at that time than did those in the control group. Increases over the day for the feeling of wonderful were found to be significant for the experimental group as compared to the control.

As can be seen from the amount of significant mood data produced by the four schools, there did appear to be mood-altering conditions present within these environments. Since this investigation was most interested in what, if any, differences may be found between the control and experimental schools, it was quite gratifying to discover significant results between schools on three of the mood scales, and on many of the individual items.

In general, students in the color/light and light only schools were found to have greater feelings of Surgency and Mastery/Self-Esteem, compared to those students in the control school. In addition, students in the color only school were significantly different from the control school only on the measures of Surgency over time, and the color only school had the lowest level of Mastery/Self-Esteem out of the four schools.

On the Aggression scale there were significant differences between the control school and two of the three experimental schools. The control school students scored significantly higher on Aggression than did those in the light only and color only schools. Surprisingly though, so did the children at the color/light school.

From the above data, it appears that the most robust and beneficial mood-altering environments were present at the color/light and light only schools. The one environmental factor which these two buildings had in common was the use of full-spectrum, as opposed to cool-white florescent lighting. Nonetheless, since other physical and methodological characteristics were not controlled for, it would be improper to infer the lighting alone was responsible for the obtained mood results. The differences found between the control and color/light school which were controlled for physical characteristics permit stating only that the conditions present at the color/light school on the days mood data was collected were found to be significantly more conducive to increasing the students' positive mood states than were those conditions present at the control school. These findings suggest a need for further study of color/light combinations under both controlled and field conditions.

TABLE 1

MAIN EFFECTS FOR SCHOOL ON MOOD SCALES

(Morning vs Afternoon Testing)

SCALE	TIME	SCHOOL	N	MEAN	F PROBABILITY
Surgency	**Morning**	**Grades 3-6**	**370**		**.01**
		Color Light	75	9.493	
		Control	126	9.984	
		Light Only	113	9.956	
		Color Only (no grade 3)	56	2.000	
Aggression	**Morning**	Color Light	75	2.840	**.049**
		Control	126	2.516	
		Light Only	113	1.876	
		Color Only (no grade 3)	56	1.911	
Mastery/ Self-Esteem	**Morning**	Color Light	75	8.600	**.008**
		Control	126	7.397	
		Light Only	113	7.841	
		Color Only (no grade 3)	56	6.214	
	Afternoon	**Grades 3-6**	**372**		**.019**
		Color Light	75	9.587	
		Control	127	8.008	
		Light Only	113	8.664	
		Color Only (no grade 3)	57	8.436	
Surgency	**Morning**	**Grades 4-6**	**314**		**.023**
		Color Light	54	9.111	
		Control	104	9.865	
		Light Only	100	9.770	
		Color Only	56	7.946	
Aggression	**Morning**	Color Light	54	3.204	.01
		Control	104	2.694	
		Light Only	100	1.880	
		Color Only	56	1.911	
Mastery/ Self-Esteem	**Morning**	Color Light	54	8.685	.013
		Control	104	7.308	
		Light Only	100	7.560	
		Color Only	56	6.214	
	Afternoon	**Grades 4-6**	**316**		**.01**
		Color Light	54	10.000	
		Control	105	8.124	
		Light Only	100	8.440	
		Color Only	57	7.421	

TABLE 2

MAIN EFFECTS FOR SCHOOL ON MOOD SCALES[a]

(Morning & Afternoon Combined)

SCALE	SCHOOL[b]	N	MEAN[c]	PROBABILITY
Aggression	**Grades 3-6**	**365**		**.050**
	Color Light	75	3.080	
	Control	124	2.887	
	Light Only	110	2.264	
	Color Only (no grade 3)	56	2.000	
	Grades 4-6	**310**		**.023**
	Color Light	54	3.139	
	Control	103	2.966	
	Light Only	97	2.206	
	Color Only	56	2.000	
Mastery/ Self-Esteem	**Grades 3-6**	**365**		**.002**
	Color Light	75	9.093	
	Control	124	7.738	
	Light Only	110	8.218	
	Color Only (no grade 3)	56	6.866	
	Grades 4-6	**310**		**.001**
	Color Light54	9.343		
	Control	103	7.733	
	Light Only	97	7.954	
	Color Only	56	6.866	

---

[a] Only F probabilities of .05 are presented.

[c] Scale means have a possible range from 0 (no mood items were applicable to the children at that time) to 15 (all mood items had the highest degree of applicability to the children at that time.)

TABLE 3

INTERACTION-EFFECTS FOR SCHOOL ON THE MOOD OF SURGENCY

Interaction	School	N	Mean	F Probability	
School-by-time	**Grades 3-6**	**365**	**Morning**	**Afternoon**	**.001**
	Color/Light	75	9.493	9.907	
	Control	124	10.032	9.556	
	Light Only	110	9.964	10.136	
	Color Only (no grade 3)	56	7.946	10.679	
	Grades 4-6	**310**			**.001**
	Color/Light	54	9.111	10.333	
	Control	103	9.961	9.495	
	Light Only	97	9.773	10.144	
	Color Only	56	7.946	10.679	

APPENDIX C

ELECTROMAGNETIC RADIATION
and
STUDENT OFF-TASK BEHAVIOR

- by -

Leon Ingraham

PLANNING SERVICES BRANCH
ALBERTA EDUCATION

July, 1983

ACKNOWLEDGEMENTS

I am indebted to many people for their assistance in the completion of this work. Special thanks are due to:

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The Wetaskiwin city school board and superintendent of schools for allowing the study in their schools.

Five teachers and their principals for their professionalism and cooperation during twenty-one days of in classroom observations.

The grade three students of Centennial and Parkdale Schools for their acceptance and cooperation of an intruder in their normal classroom setting.

The typist, Evelyn, for her excellent typing skills, understanding and cooperation.

ABSTRACT

The effects of eletromagnetic radiation emitted from fluorescent lights on the off-task behaviors of grade three elementary school pupils was studied by means of a quasi-experimental procedure. The independent variable was the level of eletromagnetic radiation which was eliminated by grounding and shielding the fluorescent light fixtures in the experimental classroom. The off-task behaviors were recorded by a reliable on-site observer for two groups of grade three pupils.

For the intact classroom group (comprised of all pupils and heterogenous with respect to hyperactivity) the elimination of electromagnetic radiation decreased significantly the rate of off-task behaviors. For triad groups (groups of three pupils selected as being most hyperactive) the results were mixed and inconclusive. Contrary to expectations, pupils from this latter group who were prone to hyperactivity, demonstrated no benefit from the elimination of electromagnetic radiation.

Since the classroom gruops demonstrated an effect from electro-magnetic radiation, further studies are suggested.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS i
ABSTRACT ii
TABLE OF CONTENTS iii
LIST OF TABLES v
LIST OF FIGURES vii
INTRODUCTION 134
PROBLEM 134
  Effect of Electromagnetic Radiation 135

DEFINITIONS 135
  Students' Off-Task Behaviors 135
  Classroom Off-Task Behaviors 135
  Triad Student Groups 136

OPERATIONAL DEFINITIONS 136
  Instrumentation 136
  Interobserver Reliability 136

METHODOLOGY 138
  Experimental Design 138
  Procedure 138
  Data Collection 139
  Data Analyses 140

TABLE OF CONTENTS (CONTINUED)

RESULTS FROM CLASSROOM GROUPS 140

Effects of Electromagnetic Radiation 140

Effects of Electromagnetic Radiation Under Controlled Lighting Conditions 141

RESULTS FROM TRAID GROUPS 145

Effects of Electromagnetic Radiation: Comparisons with Individual Traid Groups 145

Effects of Electromagnetic Radiation: Comparison of Combined Traid Groups ($C_1 + C_2$) with E_1 152

SUMMARY OF THE FINDINGS AND CONCLUSIONS 159

Summary of the Findings and Conclusions 159

Effects of Electromagnetic Radiation on Classroom Groups 159

Effects of Electromagnetic Radiation Under Controlled Lighting Conditions 159

Effects of Electromagnetic Radiation on Individual Triad Groups 159

Effects of Electromagnetic Radiation on Combined Traid Groups ($C_1 + C_2$) with E_1 160

DISCUSSION AND IMPLICATIONS FOR FURTHER STUDY 161

BIBLIOGRAPHY 164

LIST OF TABLES

Table | Page

1. Correlations Between Six Categories of Behavior and Learning Performance for LD and Non-LD Groups 137
2. Interobserver Percentage Agreement for Behavior Categories 137
3. Baseline Period Combined (C_1 & C_2) and Experimental (E_1) Classroom Off-Task Behavior 141
4. Experimental Period Combined (C_1 & C_2) and Experimental (E_1) Classroom Off-Task Behavior 141
5. Baseline Period Individual Classroom Off-Task Behavior 142
6. Baseline Period Analysis of Variance Classroom Off-Task Behavior 142
7. Experimental Period Individual Classroom Off-Task Behaviors 143
8. Experimental Period Analysis of Variance Classroom Off-Task Behaviors 143
9. Experimental Period Difference Between Groups Classroom Off-Task Behaviors 144
10. Inattentive Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation Periods 146
11. Off-Task Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation Periods 147
12. Disruptive Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation Periods 148
13. Inappropriate Location Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 150

LIST OF TABLES (CONTINUED)

Table **Page**

14. Total-Off-Task Behavior of Individual Triad Groups: Differences Betweem Baseline and Experimental Observation Periods 151

15. Inattentive Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 153

16. Off-Task Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 154

17. Disruptive Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 155

18. Inappropriate Location Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 156

19. Total-Off-Task Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods 157

LIST OF FIGURES

Figures Page

1. Inattentive Behavior of Individual Triad Groups 146
2. Off-Task Behavior of Individual Triad Groups 147
3. Disruptive Behavior of Individual Triad Groups 148
4. Inappropriate Location Behavior of Individual Triad Groups 150
5. Total-Off-Task Behavior of Individual Triad Groups 151
6. Inattentive Behavior of Combined Triad Groups 153
7. Off-Task Behavior of Combined Triad Groups 154
8. Disruptive Behavior of Combined Triad Groups 155
9. Inappropriate Location Behavior of Combined Triad Groups 156
10. Total-Off-Task Behavior of Combined Triad Groups 157

INTRODUCTION

Educators continue to seek ways of improving learning conditions for pupils. Much of this concern has focused on conditions associated with curriculum and instruction. More recently the effects of home, community, peer and pupil factors have been recognized. However, these types of non-school influences are not easily altered.

The physical settings in which pupils receive instruction sometimes are readily altered. Lighting and colors in classrooms and hallways, for example, are relatively easy to change. This potential contributed to the motivation to initiate the color/light study in Wetaskiwin elementary schools.

Since the Wetaskiwin color/light study began the principal investigator and Alberta Education personnel attended a presentation by Dr. John Ott on the effects of variations of lighting on living organisms, including humans. The effects on hyperactive children of electro-magnetic radiation generated by fluorescent lights was demonstrated by a film presentation and was of particular interest.

The research on the effects of electromagnetic radiation on children predisposed to hyperactivity in scanty. An experiment by Mayron et al. (1974) compared the effects on hyperactive behavior of grade one pupils of conventional fluorescent lights (unshielded) with full spectrum fluorescent lights (shielded). In the latter case the shielding reduced the amount of radiation. Hyperactive behavior was reduced in the particular classroom which was provided with simulated outdoor lighting and reduced radiation levels. The combinations of type of light and various radiation levels were not found to be associated with learning.

The Mayron et al. (1974) experimenta examined the combined effects of full spectrum lighting and low radiation levels on pupil behavior. The preliminary, exploratory study outlined in succeeding sections is designed to assess the effect of radiation (as a single variable) on the classroom behavior of grade three pupils.

PROBLEM

A need exists to provide optimal physical conditions in the learning environments of pupils in our schools. Electromagnetic radiation level has been suggested as one factor in the classroom environment which may have a measurable effect on pupils' behaviors. Accordingly, a study of the effects of radiation levels seemed warranted.

Effect of Electromagnetic Radiation

The main problem addressed in this study was represented by the following questions:

1) What is the effect on the hyperactive behaviors of elementary school children of reducing the electromagnetic radiation levels from fluorescent lights?

This question was answered by determining if the reduction of electromagnetic radiation by grounding and shielding full spectrum fluorescent lighting reduced student hyperactive behaviors.

DEFINITIONS

Students' Off-Task Behaviors

Inattentive behavior (IN). This behavior was identified by observing the direction of the students' eyes or the "looking" response. For example: not orienting eyes to the teacher or to the task when the teacher is instructing.

Off-task behavior (OT). This behavior was identified by observing the student in any of the following activities:

1) verbalizing or vocalizing to peer, self or teacher (re: talking to teacher--irrelevant comments/questions),

2) playing, doodling, looking out the window or passively watching the teacher or others without becoming involved in the activity,

3) proceeding with practice materials before given directions, responding before the group in choral activities or talking to peers.

Disruptive behavior (DB). This was identified only when the teacher corrected the student for behaviors such as yelling, making objectionable noises, teasing others or making interfering gestures.

Inappropriate location (IP). This category was recorded when a pupil was walking, sitting, or standing in an area that was not appropriate for the on-going academic activity in the classroom.

Total off-task behaviors (TOT). TOT is the total of the four off-task behaviors exhibited by each target student expressed as a rate for each minute of observation.

Classroom Off-Task Behaviors

Classroom off-task behaviors (COT). Classroom off-task behaviors were the number of students in the classroom during a fifteen second survey that was exhibiting any of the four target student off-task behavior categories of IN, OT, DB or IP. The number of classroom off-task behaviors was also converted to rate per minute of observation.

Triad Student Groups

Three students were selected from each classroom as target students for indepth observations using the four category observation instrument. These students were selected on the basis of exhibiting the greatest amount of hyperactive behavior over all other students in each classroom. They were selected through researcher observation and verificaton with the teacher and principal. The group of three students in each classroom was named a triad group (meaning a unit of three). These three students from each classroom were used in comparing behaviors of children who seemed to be predisposed to hyperactivity.

OPERATIONAL DEFINITIONS

Instrumentation

An electric timer affixed to a recorder board was used to provide time cues for recording target student off-task behavior. Each target student's behavior was observed for periods of one minute. Every 3 seconds of the minute the student's behavior was recorded (20 observations per minute). This timer and recorder board was also used to assist in timing the off-task observations, i.e. the collective behavior of all pupils in the class.

The four category instrument. The four category observation instrument was adopted from a Gettinger and Fayne (1982) study which measured hyperactive behavior in learning disabled and non-learning disabled students. Their observation instrument consisted of six categories of behavior: (1) inattention, (2) verbalization, (3) non-academic, (4) impulsive behavior, (5) disruptive behavior, and (6) inappropriate location. Correlations between each of the six categories of off-task behavior and learning performance for disabled and non-disabled groups of students for their study are presented in Table 1. Using these correlations as background and carryover to this study a four category observation instrument was adapted. The four categories of behaviors defined above and which comprised the observation instrument used in this study are: (1) inattentive behavior (IN), (2) off-task behavior (OT), (3) distruptive behavior (DB), (4) inappropriate location (IP).

Interobserver Reliability

A forty-five minute videotape was filmed in two classrooms where there were several students who exhibited hyperactive behavioral tendencies. This tape was used to train two observers. After initial training using the videotape, two additional observing and recording sessions were completed in classrooms for additional training. Two interobserver reliability measures were taken. The first reliability check was made the first day of the study, and the second measure was taken three weeks later during the study. The percentage agreements between the investigator and the second observer are presented in Table 2.

Table 1

Correlations Between Six Categories of Behavior and Learning Performance for LD and Non-LD Groups

Behavior Category	Initial Trials[a] (LD group only)	Retention Trials[b] (LD group only)	LD Group Posttest	Non-LD Group Posttest
Inattention	-0.16	-0.10	-0.75**	-0.38*
Verbalizations	0.02	0.04	-0.20	-0.02
Nonacademic	-0.17	-0.06	-0.68**	-0.21
Impulsive	0.12	0.02	-0.31	0.31
Disruptive	-0.03	-0.05	-0.41**	0.08
Inappropriate location	-0.11	-0.03	-0.55**	0.00

* $p < .05$
** $p < .01$

[a] Number of trials needed to read each training word correctly one time during initial instruction

[b] Number of trials needed to read each word correctly one time during review instruction.

Gettinger & Fayne (1982) Table 3, p. 185.

Table 2

Interobserver Percentage Agreement for Behavior Categories

Behavior Categories	IN	OT	DB	IP	COT
Interobserver Agreement-first measure	96	99	75	89	92
Interobserver Agreement-second measure	97	94	100	97	98

METHODOLOGY

This research project was carried out during May and early June, 1983, in two Wetaskiwin elementary schools; namely, Parkdale and Centennial Schools. The classrooms in Centennial School are equipped with conventional fluorescent lighting, while Parkdale School classrooms are equipped with full spectrum fluorescent lighting. Three grade 3 classrooms were selected for the study, one room from Centennial School which functioned as a control room and two from Parkdale School. One of the two Parkdale classrooms was used as a control room and the other functioned as the experimental room.

Experimental Design

A quasi-experimental design was developed involving three classrooms referred to as C_1, C_2, and E_1. Each classroom exhibited the following characteristics:

1) Control room one (C_1) was equipped with conventional fluorescent lighting--unshielded full electromagnetic radiation.

2) Control room two (C_2) was equipped with full spectrum fluorescent lighting--unshielded full electromagnetic radiation.

3) Experimental room (E_1) was originally equipped with full spectrum fluorescent lighting--full electromagnetic radiation. Baseline observations were recorded under these conditions. During the experimental stage the full spectrum fluorescent lighting was shielded and grounded providing the same full spectrum fluorescent lighting but nil electromagnetic radiation. The independent manipulated during the experiment was the level of electromagnetic radiation.

Procedure

The experiment was carried out in three phasees:

1) Phase one consisted of selecting three classrooms for the study and choosing three target students from within each classroom.

2) Phase two involved the collection of data from each of the three classrooms during a baseline period.

3) Phase three involved collecting data from the three classrooms during the experimental period (when electromagnetic radiation was eliminated in the experimental classroom E_1).

Phase One. Five grade three classrooms were observed for 0.5 days each. Observations of teaching strategies were recorded using a 27 item teaching strategy instrument developed by Project Quest. Ratings of classroom off-task (COT) behaviors were recorded for each class. Three target students who exhibited the most hyperactive behaviors using the Four Category Instrument were identified in each class. The three classrooms that were the most closely matched in teaching style, classroom off-task behavior and the most equivalent triad groups in relation to the four off-task behaviors were selected for inclusion in the study.

Phase two. Baseline data were collected from the three classrooms C_1, C_2, and E_1 during the first two weeks of May. Baseline data consisted of 12 thirty minute observation periods per classroom carried out on a scheduled basis yielding 72 minutes of observations per triad group of students and 33 minutes of observations for classroom off-task behavior. Observations were carried out in the core subjects only and the observations were scheduled to ensure equivalency with respect to morning, afternoon and the day of the week. Lighting arrangements for all classrooms during the baseline period were unaltered, C_1 having conventional fluorescent lighting with full electromagnetic radiation and C_2 and E1 with full spectrum fluorescent lighting and full electromagnetic radiation.

Phase three. Experimental data were collected during the latter week of May and the first two weeks of June. The experimental classroom, E_1 for this period had lead shields installed at each end of the full spectrum fluorescent bulbs, and the light shielded by a grounded aluminum screen which resulted in full spectrum lighting and nil electromagnetic radiation. Experimental data were collected for 24 thirty minute observation periods per classroom. Data collected consisted of 144 minutes of observation for each triad group of students and 66 minutes of observations per classroom.

Data Collection

Data were collected from two sources: (1) classroom off task (COT) behaviors of all students in each of the three classrooms which constituted the study, and (2) individual triad hyperactive student group members. Off-task behaviors were recorded from each of these sources from each of the three classrooms which formed the study.

Classroom off-task behaviors (COT). This was an observation of the total classroom student population. Every three minutes during a thirty minute period a 15 second survey of the room was taken and any student who was off-task by exhibiting, IN, OT, DB, or IP behavior was recorded. During a thirty minute observation period eleven such observations were recorded, since each class period began and ended with an observation.

Triad hyperactive student groups. Three students from each class were selected as target students. The students were selected on the basis of being the three most hyperactive students in the classroom by exhibiting the greatest measures of IN, OT, DB, and IP. Each student was observed for one full minute every four minutes during a thirty minute obseration period. During the minute of observations of individuals the student's behavior was recorded every three seconds in any of the four categories of IN, OT, DB, or TP. In a thirty minute observation period each student was observed for 6 minutes, every 3 seconds totalling 120 observations per thrity minute period, or 20 observations per minute.

Data Analyses

Analyses of variance procedures and t-tests were used to determine the equivalence of classroom groups and pupil triad groups during the baseline observation period. Analyses of variance and t-tests of uncorrelated means were also conducted using data collected during the experimental observation period.

For those comparisons involving groups shown to be non-equivalent during the baseline period observations (the pupil triads), (1) t-tests of change scores between baseline and experimental periods were used for each group, and (2) Analysis of Covariance procedures were used as well to adjust the experimental period averages. Subsequently, for multiple pair-wise comparisons the Sheffe procedure was employed ($p < .10$).

RESULTS FROM CLASSROOM GROUPS

Effects of Electromagnetic Radiation

The major question which provided direction to the investigation was: Does electromagnetic radiation affect elementary school children's hyperactive off-task behaviors?

The results in Table 3 indicate there was very little difference, 0.73 (not statistically significant) total off-task behaviors per minute, between baseline comparisons of the combined classrooms C_1 and C_2 (full electromagnetic radiation) and classroom E_1 (full eletromagnetic radiation). This finding indicates the classrooms were very similar in student total off-task behaviors per minute during the baseline period. As a consequence, direct comparisons of experimental period behaviors between groups was warranted to determine the effects of electromagnetic radiation. Differences could be attributed to radiation levels and not to initial baseline behavior patterns.

Table 4 indicates there was a significant difference of 3.15 total off-task behaviors per minute during the experimental period in comparisons between the combined classroom (C_1 & C_2; full electromagnetic radiation) and the experimental classroom (E_1; nil electromagnetic radiation). The experimental classroom (E_1) showed a reduction of 3.15 total off-task behaviors per minute which is significant at the $p. < .01$ level. This finding supports the conclusion that reducing electromagnetic radiation from full spectrum lighting will reduce hyperactive student behavior in classroom groups.

Table 3

Baseline Period Combined (C_1 & C_2) and Experimental (E_1) Classroom Off-Task Behavior

Group	No. of 30 min. Observations	Mean Off-Task Behaviors/min.	Standard Deviation
Combined comparisons classes (C_1 & C_2)	24	12.73	4.98
Experimental class (E_1)	12	12.00	5.35
Difference		.73	

Table 4

Experimental Period Combined (C_1 & C_2) and Experimental (E_1) Classroom Off-Task Behavior

Group	No. of 30 min. Observations	Mean Off-Task Behaviors/min.	Standard Deviation
Combined comparisons classes (C_1 & C_2)	48	12.23	4.754
Experimental class (E_1)	24	9.07	4.754
Difference		3.15**	

** $p < .01$

Effects of Electromagnetic Radiation Under Controlled Lighting Conditions

A second question addressed in the study was: What is the effect on student hyperactive behavior when electromagnetic radiation is reduced in full spectrum lighting?

Table 5 presents a comparison of student total-off-task behaviors per minute during baseline data among classroom C_1, C_2, and E_1. There was a difference observed among the mean off-task behaviors per minute. The averages ranged from 13.27, 12.20, and 12.00 behaviors per minute in classrooms C_1, C_2 and E_1, respectively. Results from the analysis of variance (Table 6) indicate there were no significant difference among the three calssrooms; the classrooms were equivalent in student total off-task behaviors during the baseline period.

Table 5

Baseline Period Individual Classroom Off-Task Behavior

Group	No. of 30 min. Observations	Mean Off-Task Behaviors/min.	Standard Deviation
Comparison class (C_1)	12	13.27	6.20
Comparison class (C_2)	12	12.20	3.57
Experimental class (E_1)	12	12.00	5.35

Table 6

Baseline Period Analysis of Variance Classroom Off-Task Behavior

Source	Sum of Squares	Degrees of Freedom	Mean of Squares	F	Probability
Groups	11.39	2	5.70	0.24	0.81
Error	877.41	33	26.59		
Total	888.80	35			

Table 7 provides a comparison of student total off-task behaviors per minute during the experimental period among classrooms, C_1 (conventional lighting; full electromagnetic radiation), C_2 (full spectrum full electromagnetic radiation), and E_1 (nil electromagnetic radiation). The table indicates there is a difference of mean off-task behaviors per minute. The behaviors per minute range from a high of 12.88 found in C_2 to 11.58 in C_1 to a low of 9.07 in E_1. This set of total off-task behaviors were subjected to an analysis of variance to ascertain if any of the differences between groups were statistically significant.

Table 7

Experimental Period Individual Classroom Off-Task Behaviors

Group	No. of 30 min. Observations	Mean Off-Task Behaviors/min.	Standard Deviation
Comparison class (C_1)	24	11.58	5.06
Comparison class (C_2)	24	12.88	4.44
Experimental class (E_1)	24	9.07	4.72

Table 8 indicates there was a significant difference found at the p. .05 level. At least one of the pair-wise comparisons between groups was significant.

Table 8

Experimental Period Analysis of Variance Classroom Off-Task Behaviors

Source	Sum of Squares	Degrees of Freedom	Mean of Squares	F	Probability
Groups	179.55	2	89.78	3.98*	0.02
Error	1555.12	69	22.52		
Total	1734.67	71			

* $p < .05$

Table 9 indicates that the difference between the two classrooms with full spectrum fluorescent lights (E_1 and C_2) is 3.81 total off-task behaviors per minute. The experimental classroom (E_1; nil electromagnetic radiation) students showed a significant reduction of total off-task behaviors. This finding demonstrates that grounding and shielding electromagnetic radiation from full spectrum lighting will reduce hyperactive behavior of pupils in heterogeneous classroom groups.

Table 9

Experimental Period Differences Between Groups
Classroom Off-Task Behaviors

Group	Differences in Off-Task Behaviors/min. Comparison Group C_1 (Conventional Lighting and Full Radiation)	Experimental Group E_1 (Full Spectrum Non-Radiation)
Comparison Group C_2 (Full Spectrum and Full Radiation	1.30	3.81*
Experimental Group E_1 (Full Spectrum and Non-Radiation	2.50	

* $p < .10$ using the Scheffe multiple range pair-wise comparison test.

As expected the difference of 1.3 total off-task behaviors per minute between the classroom with conventional fluorescent lighting (C_1; unshielded) and the classroom with full spectrum lighting (C_2; unshielded) was not statistically significant. Differences here were not expected since the classrooms were matched with respect to behavior patterns during initial selection and radiation levels were not manipulated. The final comparison in Table 9 indicates that the difference between conventional lighting with full electromagnetic radiation (C_1) and full spectrum lighting with nil electromagnetic radiation (E_1) favored the experimental group. There was a reduction of 2.5 total off-task behaviors per minute, attributable to elimination of electromagnetic radiation. However, this difference was not statistically significant.

RESULTS FROM TRIAD GROUPS

Effects of Electromagnetic Radiation: Comparisons with Individual Triad Groups

The data from this section, as explained under methodology, were collected from a group of 3 most hyperactive students (referred to as a triad group) in each of the 3 classrooms: C_1, C_2, and E_1. The data were collected using the four category instrument which yielded 5 sets of measurements of hyperactive student off-task behaviors. Five measurements were identified as inattentive behavior (IN), off-task behavior (OT), disruptive behavior (DB), inappropriate location (IP), and total off-task behaviors (the sum of IN, OT, DB, IP and TOT). Comparisons were made between behaviors during the baseline period and experimental period within each of the C_1, C_2 and E_1 Triad Groups.

Data Analysis was carried out to answer the original question: Does electromagnetic radiation affect hyperactive elementary school children's off-task behaviors?

Comparisons of inattentive behavior are listed in Table 10 and portrayed in Figure 1, for the 3 individual triad groups. The mean, standard deviation, and number of one minute observations are listed for each triad group C_1, C_2 and E_1 comparing baseline period to experimental period. The differences between baseline and experimental data were compared by analysis of variance procedures. The within-group comparisons for Triad Groups C_1 and E_1 showed positive differences for Inattentive Behavior. That is, for each of these groups the frequency of inattentive behaviors increased in the experimental period compared to the baseline period. For the E_1 Group the increase in rate of 1.07 inattentive behaviors per minute was statistically significant (p .01). This finding was not expected. For Triad Group C_2 the rate of inattentive behaviors decreased by 0.38 behaviors per minute but this difference was not statistically significant.

Off-task behaviors of individual triad groups are tabulated in Table 11 and graphically portrayed in Figure 2. The difference between baseline and experimental period means for C_1 and C_2 were 0.21 and 0.70, respectively. Analysis of variance indicated these increases were not significant. The difference between baseline and experimental means for E_1 was -1.67 which is significant at $p < .01$. The average number of off-task behaviors per minute was less during the experimental period than the baseline period indicating that conditions of full spectrum fluorescent lighting, nil electromagnetic radiation, reduced hyperactive student off-task behavior.

The triad groups disruptive behaviors for baseline and experimental periods are represented in Table 12 for each of the individual groups. The difference of the means for C_1, C_2 and E_1 were -0.29, -0.18, and -0.14, respectively and each difference is significant $p < .01$ level. All three groups' disruptive behaviors were reduced to zero during the experiemntal period. The differences between baseline and experimental means are presented in Figure 3. Electromagnetic radiation was controlled during the experimental period for E_1 Group only. With all three groups' disruptive behaviors being reduced significantly and reaching zero a possible interaction of another variable is indicated.

Table 10

Inattentive Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation periods

		Behaviors Per Minute		
Group	Descriptive Statistic	Baseline Period	Experimental Period	Difference
C_1 ○	$\bar{X}$	1.68	2.17	0.49
	S.D.	3.58	4.59	
No. of 1 minute observations		216	432	
C_2 □	$\bar{X}$	2.25	1.87	-0.38
	S.D.	3.74	4.04	
No. of 1 minute observations		216	432	
E_1 △	$\bar{X}$	1.69	2.76	1.07**
	S.D.	3.10	4.84	
No. of 1 minute observations		216	432	

** $p < .01$

Figure 1
Inattentive Behavior (Re: Table 10)

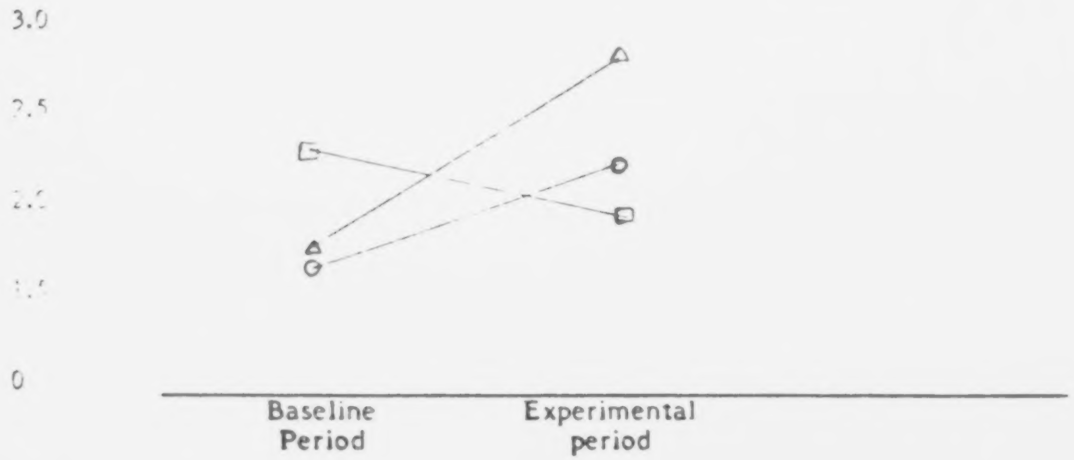


Table 11

Off-Task Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation periods

Group	Descriptive Statistic	Behaviors Per Minute Baseline Period	Experimental Period	Difference
C_1 ○	$\bar{X}$	2.38	2.59	0.21
	S.D.	4.78	5.09	
No. of 1 minute observations		216	432	
C_2 □	$\bar{X}$	3.24	3.94	0.70
	S.D.	5.56	5.77	
No. of 1 minute observations		216	432	
E_1 △	$\bar{X}$	4.19	2.52	-1.67**
	S.D.	5.85	4.47	
No. of 1 minute observations		216	432	

** $p < .01$

Figure 2
Off-Task Behavior (Re: Table 11)

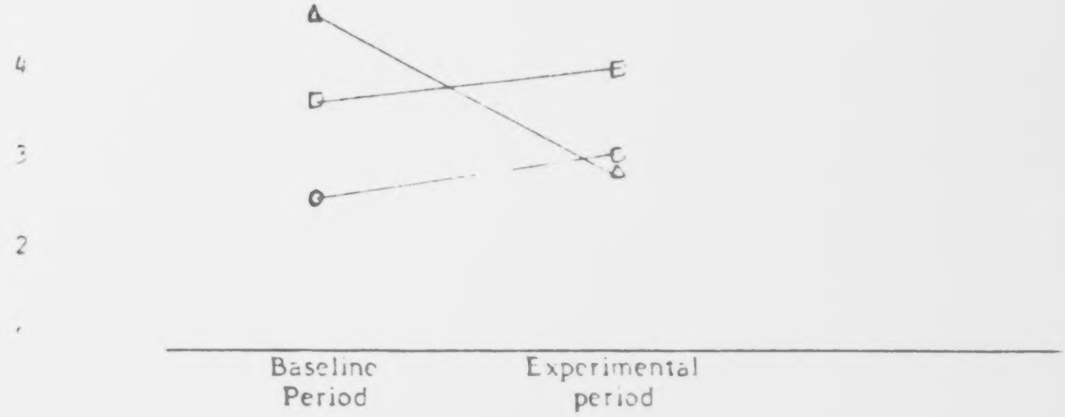


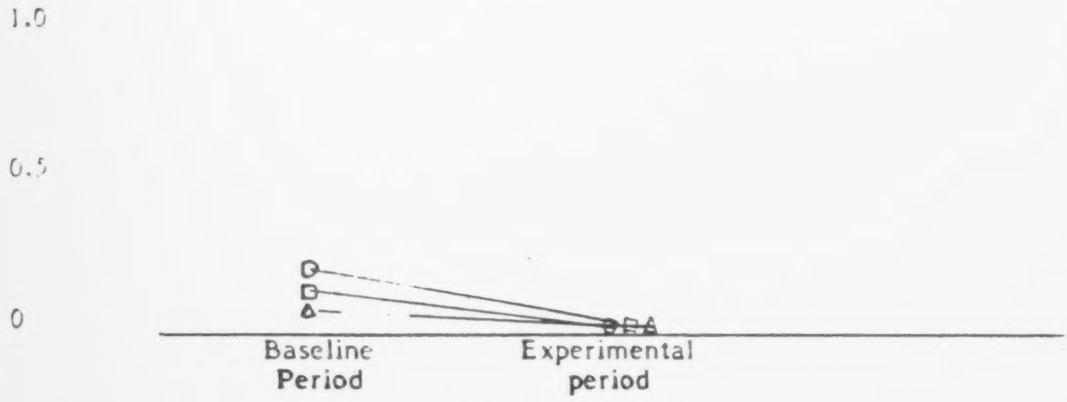
Table 12

Disruptive Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation periods

		Behaviors Per Minute		
Group	Descriptive Statistic	Baseline Period	Experimental Period	Difference
C_1 ○	$\bar{X}$	0.29	0.0	0.29**
	S.D.	1.60	0.0	
No. of 1 minute observations		216	432	
C_2 □	$\bar{X}$	0.18	0.0	0.18**
	S.D.	1.18	0.0	
No. of 1 minute observations		216	432	
E_1 △	$\bar{X}$	0.14	0.0	0.14**
	S.D.	0.69	0.0	
No. of 1 minute observations		216	432	

** $p < .01$

Figure 3
Disruptive Behavior (Re: Table 12)



The researcher suggests that the other variable may have been that of students becoming familiar with and accepting the researcher's presence in the classroom without acting up, which may have caused earlier levels of disruptive behavior exhibited during the baseline period.

Students' Behavior of Inappropriate Location are presented in Table 13 for each individual triad group, C_1, C_2 and E_1. The difference between baseline and experimental means is -0.20, -0.18 and 0.29, respectively. Analysis of variance of the differences between means for E_1 showed that the difference of 0.29 as being significant at $p < .05$. The difference between means is graphically represented in Figure 4 which illustrates an increase in inappropriate location for E_1, experimental period (full spectrum fluorescent lighting shielded and grounded; nil electromagnetic radiation). No significant increases were noted for the groups experiencing full electromagnetic radiation.

Total Off-Task Behaviors for the three triad groups C_1, C_2 and E_1 are presented in Table 14. The differences between the means, baseline data vs. experimental data, for the sum of the four categories of Off-Task Behaviors for each triad group, C_1, C_2 and E_1 are 0.20, 0.03 and -0.46, respectively. Analysis of variance indicates no significant differences between baseline and experimental period rates. However, Figure 5 illustrates an increase in total off-task behavior for C_1 and C_2 groups and a decrease in total off-task behavior for E_1. These differences are not significant when tested by analysis of variance but when viewed graphically are indicative that E_1 experimental (full spectrum fluorescent lighting grounded and shielded; nil electromagnetic radiation) may reduce overall hyperactive student off-task behavior.

There were five sets of data analyzed for each individual triad group comparing the differences between the means from the baseline period and the experimental period concerning hyperactive students' off-task behaviors. One behavior, inattentive behavior, increased significantly, ($p < .01$) during the experimental period (full spectrum fluorescent lighting, grounded and shielded; nil electromagnetic radiation), providing the reverse of the expected effect. Off-Task Behavior was reduced significantly ($p < .01$) for Group E_1 during the experimental period (full spectrum fluorescent lighting, grounded and shielded; nil electromagnetic radiation) which supported the expected effect. Disruptive Behavior was reduced significantly at ($p < .01$) during the experimental period for all three triad groups, C_1, C_2 amd E_1. This suggested that a variable other than nil electromagnetic radiation was a possible factor. Hyperactive student behavior, inappropriate location, increased ($p < .01$) during the experimental period E_1 only. This again was the opposite effect expected for nil electromagnetic radiation (full spectrum fluorescent lighting grounded and shielded). There were no significant results for Total-Off-Task Behaviors during the experimental period. During the experimental period E_1 (nil electromagnetic radiation) Total-Off-Task Behaviors were reduced while C_1 and C_2 behaviors increased slightly, which may indicate an overall tendency to a reduction of student Total-Off-Task Behaviors when full spectrum fluorescent lighting is shielded and grounded resulting in nil electromagnetic radiation.

The results of this portion of the study provide no evidence to indicate that reducing electromagnetic radiation from full spectrum fluorescent lighting will reduce off-task behaviors of students selected because of their propensity of hyperactive behaviors.

Table 13

Inappropriate Location Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods

Group		Descriptive Statistic	Behaviors Per Minute		
			Baseline Period	Experimental Period	Difference
C_1	○	$\bar{X}$	0.30	0.10	0.20
		S.D.	1.78	0.81	
No. of 1 minute observations			216	432	
C_2	□	$\bar{X}$	0.39	0.21	0.18
		S.D.	1.72	1.47	
No. of 1 minute observations			216	432	
E_1	△	$\bar{X}$	0.26	0.55	0.29*
		S.D.	1.23	2.10	
No. of 1 minute observations			216	432	

* $p < .05$

Figure 4
Inappropriate Location Behavior (Re: Table 13)

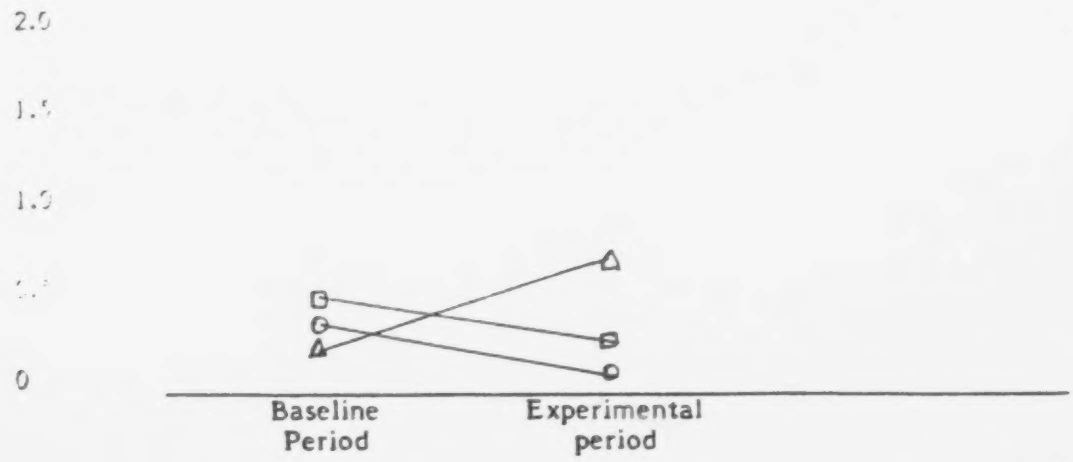
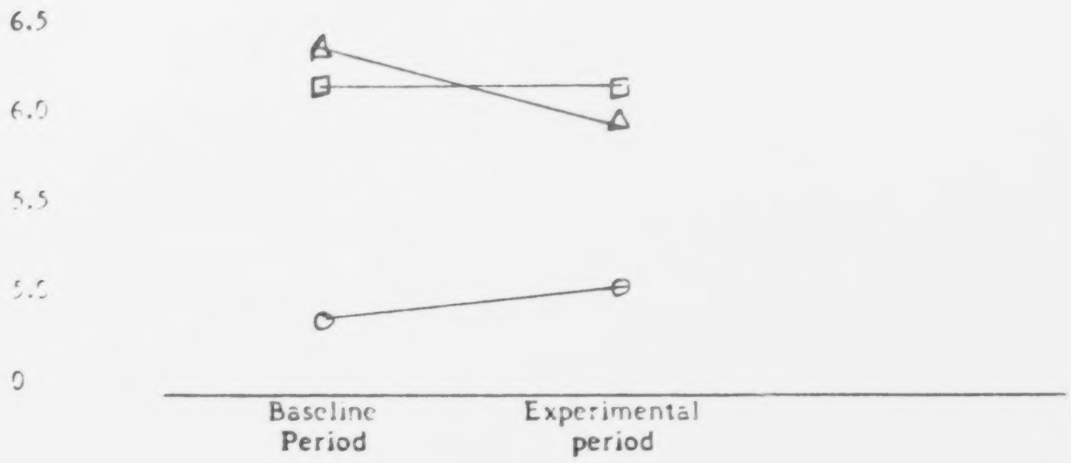


Table 14

Total-Off-Task Behavior of Individual Triad Groups: Differences Between Baseline and Experimental Observation Periods

			Behaviors Per Minute		
Group		Descriptive Statistic	Baseline Period	Experimental Period	Difference
C_1	○	$\bar{X}$	4.60	4.86	0.25
		S.D.	6.13	6.17	
No. of 1 minute observations			216	432	
C_2	□	$\bar{X}$	6.05	6.02	0.03
		S.D.	6.92	6.26	
No. of 1 minute observations			216	432	
E_1	△	$\bar{X}$	6.28	5.82	0.46
		S.D.	6.29	5.96	
No. of 1 minute observations			216	432	

Figure 5
Total-Off-Task Behavior (Re: Table 14)



Effects of Electromagnetic Radiation: Comparison of Combined Triad Groups ($C_1 + C_2$) with E_1.

The five measures, IN, OT, DB, IL and TOT, were used again to compare baseline period data (full electromagnetic radiation for all groups) to experimental period data (with electromagnetic radiation eliminated for Group E_1). Two sets of data were used, C_1 data and C_2 data were combined and compared to E_1.

Comparisons of Inattentive Behavior are listed in Table 15 for the two groups, (C_1 + C_2) and E_1. The mean, standard deviation, and number of one minute observations are listed for each group, combined (C_1 + C_2) and E_1, comparing baseline data to experimental data. The differences between means from baseline to experimental were subjected to t-test comparisons to test for significance of differences. The difference for E_1 baseline to experimental was significant at $p < .001$ level. However, the difference of 1.06 was an increase in inattentive behavior recorded during the experimental period (nil electromagnetic radiation) which was contrary to expectation. There was no significant difference within the combined group between baseline and experimental periods. The results are illustrated graphically in Figure 6.

Off-Task Behaviors of the combined group (C_1 + C_2) and E_1 are tabulated in Table 16. The difference between baseline and experimental period means for (C_1 + C_2) and E_1 were 0.46 and -1.67, respectively. The reduction from E_1 baseline to E_1 experimental was significant at the $p < .001$ level. The average number of off-task behaviors per minute was less during the experimental period than the baseline period indicating reduced hyperactive student off-task behavior. A graphic representation of the differences is presented in Figure 7.

Disruptive Behaviors for baseline and experimental periods are presented in Table 17. The differences between the means from baseline to experimental for (C_1 + C_2) and E_1, are -0.23 and -0.14, respectively. The difference for (C_1 + C_2) is significant at the $P. < .01$ level and for E_1 at the $p < .001$ level. The disruptive behaviors were reduced to zero during the experimental stage for both triad groups. Again, as in the comparison of disruptive behaviors for individual groups, this indicates the possible effect of another variable (reaction to the observer during baseline recordings) in addition to reducing electromagnetic radiation from full spectrum fluorescent lighting, during the experimental period. Due to the unknown influence of the observer on students' disruptive behavior these results are not conclusive.

Inappropriate Location Behaviors by Students are presented in Table 18 for combined triad groups (C_1 + C_2) and E_1. The difference between baseline and experimental means is -0.19 and 0.29, respectively. The differences between the baseline and experimental means were significant at $p < .01$. The difference between the means is graphically represented in Figure 9 which illustrates an increase in student inappropriate location for E_1, experimental period (full spectrum fluorescent lighting shielded and gounded; nil electromagnetic) and a decrease for the C_1 and C_2 groups exposed to full electromagnetic radiation. Both of these results are contrary to the expected effect.

Total Off-Task Behaviors for the combined triad groups (C_1 + C_2) and E_1 are presented in Table 19. The difference between the average rates for baseline and experimental periods for the sum of the four categories of Off-Task Behaviors for

Table 15

Inattentive Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation periods

Group	Descriptive Statistic	Behaviors Per Minute		
		Baseline Period	Experimental Period	Difference
$C_1 + C_2$ ▣	$\bar{X}$	1.96	2.02	0.06
	S.D.	3.66	4.32	
No. of 1 minute observations		432	864	
E_1 △	$\bar{X}$	1.69	2.75	1.06***
	S.D.	3.10	4.84	
No. of 1 minute observations		216	432	

*** $p < .001$

Figure 6
Inattentive Behavior (Re: Table 15)

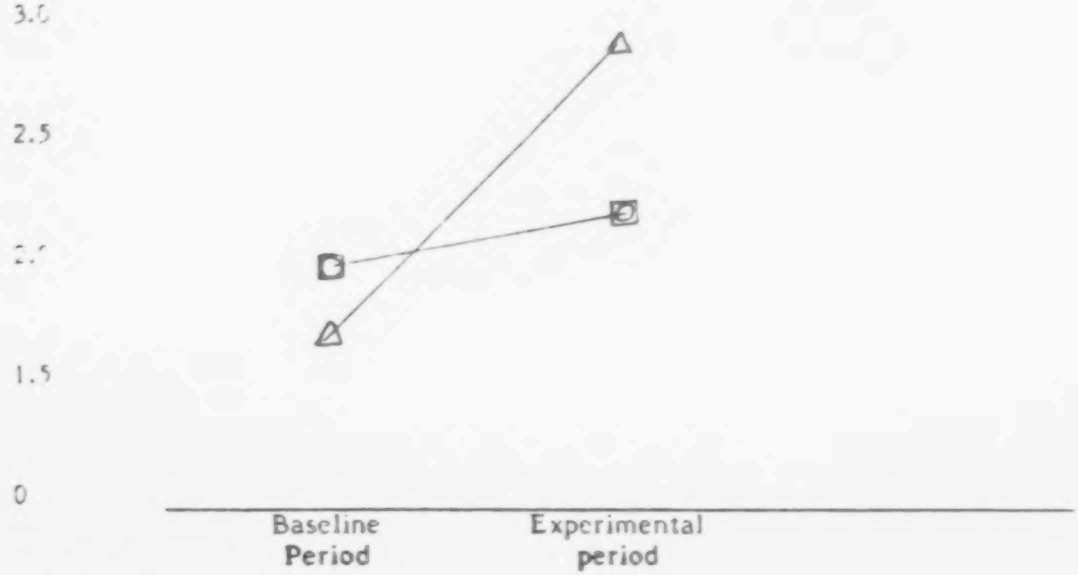


Table 16

Off-Task Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods

			Behaviors Per Minute		
Group		Descriptive Statistic	Baseline Period	Experimental Period	Difference
$C_1 + C_2$	▣	$\bar{X}$	2.81	3.27	0.46
		S.D.	5.20	5.48	
No. of 1 minute observations			432	864	
E_1	Δ	$\bar{X}$	4.19	2.52	1.67***
		S.D.	5.85	4.47	
No. of 1 minute observations			216	432	

*** $p < .001$

Figure 7
Off-Task Behavior (Re: Table 16)

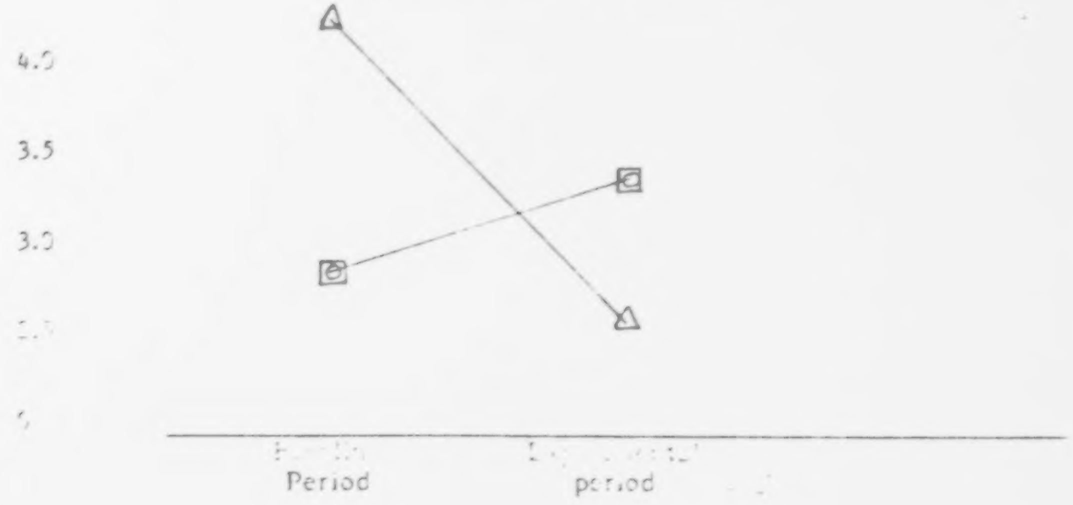


Table 17

Disruptive Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods

			Behaviors Per Minute		
Group		Descriptive Statistic	Baseline Period	Experimental Period	Difference
$C_1 + C_2$	▣	$\bar{X}$	0.23	0.0	0.23**
		S.D.	1.40	0.0	
No. of 1 minute observations			432	864	
E_1	Δ	$\bar{X}$	0.14	0.0	0.14***
		S.D.	0.69	0.0	
No. of 1 minute observations			216	432	

** $p < .01$
*** $p < .001$

Figure 8
Disruptive Behavior (Re: Table 17)

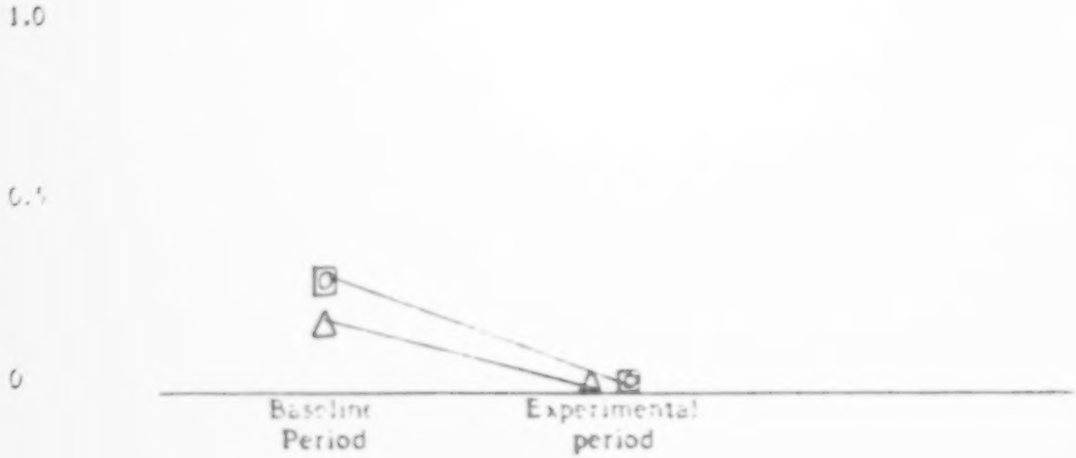


Table 18

Inappropriate Location Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods

			Behaviors Per Minute		
Group		Descriptive Statistic	Baseline Period	Experimental Period	Difference
$C_1 - C_2$	⊡	$\bar{X}$	0.35	0.16	0.19**
		S.D.	1.75	1.19	
No. of 1 minute observations			432	864	
E_1	△	$\bar{X}$	0.26	0.55	0.29**
		S.D.	1.23	2.10	
No. of 1 minute observations			216	432	

** $p < .01$

Figure 9
Inappropriate Location Behavior (Re: Table 18)

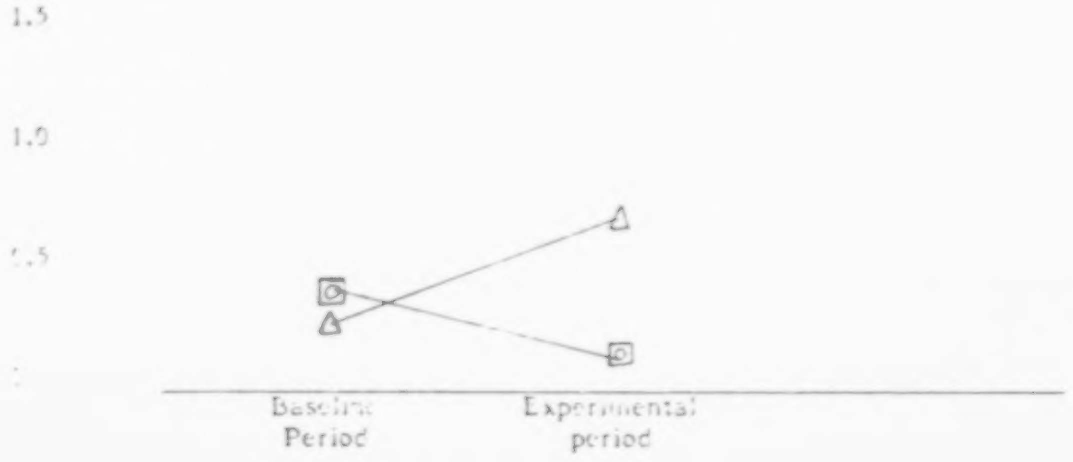
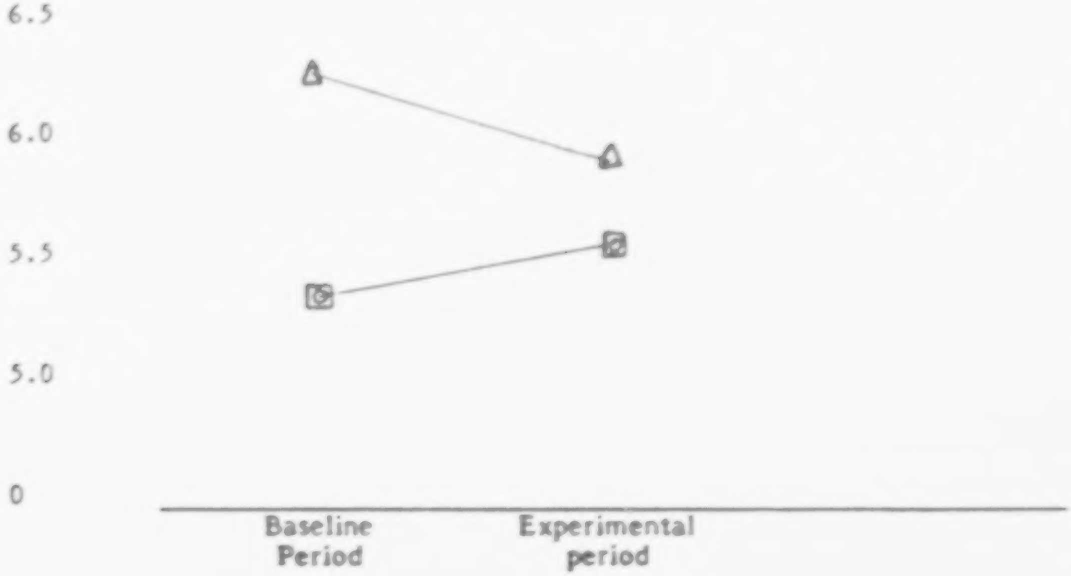


Table 19

Total Off-Task Behavior of Combined Triad Groups: Differences Between Baseline and Experimental Observation Periods

		Behaviors Per Minute		
Group	Descriptive Statistic	Baseline Period	Experimental Period	Difference
$C_1 + C_2$ ⊡	$\bar{X}$	5.35	5.44	0.09
	S.D.	6.57	6.24	
No. of 1 minute observations		432	864	
E_1 △	$\bar{X}$	6.28	5.82	0.46
	S.D.	6.29	5.96	
No. of 1 minute observations		216	432	

Figure 10
Total Off-Task Behavior (Re: Table 19)



each group, combined ($C_1 + C_2$) and E_1 are 0.09 and -0.46, respectively. Analysis of t-test indicates no significant differences. However, Figure 10 illustrates an increase in total-off-task behaviors for the combined group and a decrease in total off-task behavior for E_1, baseline data to experimental data. These differences were shown not to be significant when subjected to t-tests.

There were five sets of data analyzed for each of the two triad groups, combined ($C_1 + C_2$) and E_1, comparing the differences betwen the means of baseline data and experimental data collected from hyperactive students' off-task behaviors. The results were much the same as for the three individual triad groups.

1) Inattentive Behavior increased ($p < .001$) during the experimental period for Group E_1 (full spectrum fluorescent lighting, grounded and shielded; nil electromagnetic radiation) providing the reverse of the expected effect.

2) Off-Task Behavior was reduced significantly ($p. < 001$) for Group E_1 during the experimental period (full spectrum fluorescent lighting, grounded and shielded; nil electromagnetic radiation) which supported the effect expected. During this period the off-task behaviors for the comparison Group ($C_1 + C_2$; full electromagnetic radiation) increased, but not significantly.

3) Disruptive Behavior was reduced significantly ($p < .01$) for the combined Group ($C_1 + C_2$) and for E_1 ($p. < .001$) during the experimental period. This indicated that another variable in addition to electromagnetic radiationlevels may have been a factor.

4) Inappropriate Location Behaviors increased for both the combined group ($C_1 + C_2$) and E_1 ($p < .01$) during the experimental period. This again was the directly opposite effect expected for nil electromagnetic radiation (full spectrum fluorescent lighting grounded and shielded.

5) For Total-Off-Task Behaviors during the experimental period the Total-Off-Task Behaviors were reduced for Group E_1 (nil electromagnetic radiation), while the Combined Traid Group's Total-Off-Task Behaviors increased slightly. These differences were in the expected direction. However, the differences did not reach statistical significance.

The results of this portion of the study parallel those for individual triad groups, providing little evidence to indicate that reducing electromagnetic radiation from full spectrum fluorescent lighting will reduce off-task behavior of pupils exhibiting relatively high levels of hyperactivity.

Since the triad groups were not shown to be equivalent during the baseline period with respect to specific behaviors and total off-task behavior, direct comparisons using experimental period information were not appropriate. Differences in behavior levels during the experimental period would be partly a function of differences exhibited during baseline observations. To adjust experimental period levels to take account of initial differences analysis of covariance procedures were used with the baseline period behavior rates used as the covariates. For all specific behaviors and for Total-Off-Task Behavior, comparisons of the adjusted experimental period means revealed no significant differences among groups. These analyses provided additional support for the conclusion that, for the sub-groups (triads) of pupils exhibiting the most hyperactivity, reducing radiation levels had no effect.

SUMMARY OF THE FINDINGS AND CONCLUSIONS

This section consists of three parts. First, a summary of the findings of the study are presented. Second, conclusions based on these findings are proffered. Third, implications for expanded studies of Electromagnetic Radiation and Student Off-Task Behaviors aer provided.

Summary of the Findings and Conclusions

Three areas of the study are reported. These are:

1) Results and conclusions for classroom groups.

2) Results and conclusions from comparisons of individual triad groups.

3) Results from the two combined triad groups ($C_1 + C_2$) and E_1.

Effects of Electromagnetic Radiation on Classroom Groups

The major question which directed this portion of the investigation was: Does electromagnetic radiation affect elementary school children's hyperactive off-task behaviors? Results of this portion of the study are expressed as Classroom Off-Task Behavior (COT) and indicated a reduction of 3.15 total off-task behaviors per minute (significant at $p < .01$ level) during the experimental period for Group E_1 (nil electromagnetic radiation). This finding supports the conclusion that reducing electromagnetic radiation from full spectrum lighting will reduce hyperactive student behavior in classroom groups.

Effects of Electromagnetic Radiation Under Controlled Lighting Conditions

A secondary question was addressed in this section of the study, namely, what is the effect on off-task behavior when electromagnetic radiation is reduced under conditions of full spectrum lighting? An answer to the question is provided by interpreting the difference between the two classrooms with full spectrum fluorescent lighting (E_1 and C_2). The difference is 3.81 (significant of $p < .10$ level using Scheffe multiple range pair-wise comparison), total-off-task behaviors per minute. The experimental classroom (E_1; nil electromagnetic radiation) students showed a reduction of total-off-task behaviors. This finding supports the conclusion that grounding and shielding electromagnetic radiation from full spectrum lighting will reduce hyperactive behavior in heterogeneous groups of students.

Effécts of Electromagnetic Radiation on Individual Triad Groups

Patterns of inattentive (IN, off-task (OT), disruptive (DB), inappropriate locatin (IL) and total-off-task (TOT) behaviors of groups of three pupils (triads) selected as being most hyperactive were recorded for each of group C_1, C_2 and E_1 during each period of data collection, (baseline and experimental). The within-group differences between means were calculated, comparing baseline data to experimental data, and tests for significance of differences were made. The results were as follows:

1) Inattentive behavior increased significantly ($p < .01$) during the experimental period for the E_1 group, opposite to the expected results. No significant differences were noted for the comparison groups.

2) Off-task behavior reduced significantly ($p < .01$) during the experimental period for Group E_1 and this supported the hypotheses that electromagnetic radiation increases this type of behavior. Once again, there were not significant changes for the comparison groups.

3) Disruptive behavior reduced significantly ($p < .01$) during the experimental period for all three groups, C_1, C_2 and E_1, suggesting the influence of another variable (reactivity to presence of the observer during the baseline period).

4) Inappropriate location behavior increased significantly ($p < .01$) for the experimental group during the experimental period, the opposite of the expected results. No significant differences were noted for the comparison groups.

5) Total-off-task behavior showed no significant change during the experimental period for any of the groups. During the experimental period E_1 (nil electromagnetic radiation) total-off-task behaviors were reduced while total-off-task student behaviors increased in the two control triad groups C_1 and C_2.

The overall results from comparisons of IN, OT, DB, IL and TOT behaviors for individual triad groups showed mixed results and no consistent decrease in unwanted behaviors. There was no support for the conclusion that the practice of controlling electromagnetic radiation in full spectrum lighting will reduce off-task behaviors of pupils predisposed to hyperactivity.

Effects of Electromagnetic Radiation on Combined Triad Groups ($C_1 + C_2$) with E_1

The same measures of IN, OT, DB, IL and TOT were used for this comparison. The measures recorded for $C_1 + C_2$ were combined to facilitate a comparison of the combined control groups with the experimental group. Again the difference between means was calculated, comparing baseline period behavior to experimental period data and tests for statistical significance of differences were made. The results were similar to the individual triad group comparisons and were as follows:

1) Inattentive behavior increased significantly ($p < .001$) during the experimental period for E_1 (nil electromagnetic radiation) but not for the comparison group (full electromagnetic radiation).

2) Off-task behavior reduced significantly ($p < .001$) during the experimental period for E_1 (nil electromagnetic radiation) but not for the comparison group.

3) Disruptive behavior reduced significantly ($p < .01$) for each of the combined group ($C_1 + C_2$) and the experimental group (E_1). This suggested the effect of another variable other than electromagnetic radiation levels.

4) Inappropriate location behavior increased significantly ($p < .01$) for both groups during the experimental period.

5) Total-off-task behaviors exhibited no significant change during the experimental period. There was a noted reduction in total-off-task behavior for E_1 during this period. However, the difference was not significant.

The overall results indicated no consistent reduction of hyperactive student off-task behavior. Therefore, there was no support for reducing electromagnetic radiation from full spectrum lighting to reduce off-task behaviors for sub-groups of students inclined to hyperactivity.

DISCUSSION AND IMPLICATIONS FOR FURTHER STUDY

The findings from the intact classroom groups during this study indicated there was a possible cause-effect relationship between electromagnetic radiation and classroom students' off-task behaviors. The literature indicates (Mayron et al., 1974) that electromagnetic radiation affects learning disabled students' levels of hypeactive off-task classroom behavior. The results from this study concerning students selected for hyperactive behavior did not support Mayron's findings. The current study was a preliminary one, the purpose being to identify relationships between electromagnetic radiation and student off-task behavior, to determine if further study is warranted and to establish parameters and implications for further study.

Results from the current investigation were supportive of larger, more broadly based studies. Further studies need to be preceded by a literature review on electromagnetic radiation effects and including types of lighting and the physiological effects of light. Follow-up investigations may include one or more of the following:
(1) a replication study, (2) an expansion of the current study, and (3) a longitudinal study.

Literature Review

A literature review would assist to define the parameters of the study, synthesize the research completed in this field, and the importance and significance of the topic for the researchers and the readers. A study of selected literature written by Hathaway (1981), Rivers (1983), Hollwich (1979), Mayron et al. (1974) and Ott (1968, 1976) defines, compares and contrasts natural sunlight, incandescent light, conventional fluorescent light, full spectrum light, and the effects these types of lighting have on plants and animals including humans. These authors introduce such topics as the incomplete spectrum, the monotonous repetition of wavelengths and the flickering in artificial lighting which cause tiredness to the eye muscle, disfunctioning of the pineal glad, fatigue, and other injuries to the nervous system, including hyperactivity.

A Replication Study

The results of this study, an indication there was a cause-effect relationship between electromagnetic radiation and classroom students' off-task behaviors, needs further verification since this may be among the first reported results. There were only five grade three classrooms from which to choose three classes somewhat equivalent with respect to students' behaviors and teaching styles.

Expansion of the Study

The study was limited to three classroom of third grade students. When selecting three students from each classroom to form the triad groups the students were selected on the basis of those who exhibited the most hyperactive tendencies, judged by the number of total-off-task behaviors. The study could be expanded to allow for the selection of identical groups of hyperactive learning disabled students, classrooms exhibiting similar ability range, distribution by sex, varying grade levels and environmental factors, and similar teaching styles.

The three classrooms selected varied in amount of natural light which supplemented artificial light. More broadly based studies could involve windowless classrooms thus ruling out any variable which may be present when natural light supplements artificial light.

Longitudinal Study

The duration of this study was limited to 21 days: 3 days selecting classrooms and target students, 6 days of baseline data collection, light change, and immediate collection of experimental data for 12 days. The study was conducted during Mid May to Mid June. A longitudinal study would allow for a longer period of time to select students and classrooms. A longer period of time between baseline data collection, change of lighting and collection of experimental data may accent the results of the study by allowing more time for students and teachers to adjust to the experimental lighting conditions. Observations could be recorded at intervals over a longer span year.

The study of electromagnetic radiation, type of lighting and the effects on student off-task behavior is a frontier area of study. Lucien Royer (1983) succinctly captures the seriousness and significance of continued study in his statement:

> We definitely need more research done in this area . . . . In the meantime, we are all participating in a living experiment as to the effect of fluorescent lights on our lives. But this time we have no control group.
>
> (Royer in Rivers, 1983)

Alberta Education, through continued study in this field by replication and expansion of the present study would share the responsibility and satisfaction of further research.

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APPENDIX D

Ultraviolet Light and Dental Cavities in Children.

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IN PRESS

APPENDIX E

Measurement of UV From Fluorescent Lighting in Wetaskiwin Schools - 15 September, 1982

The levels of UV measured in grade 5 classrooms of selected elementary schools are given below. The levels are in microwatts per square centimetre (uW/cm^2) for various distances, D, measured from the lower surface of the tubes. Details of instruments used are given on attachment I.

Key: N = Norwood School; P = Parkdale School; M = C.B. McMurdo School,
and + Lo = with louvre; + Le = with lens; = without louvre or lens

D (cm)	=	0	5	50	135	Desk Top*
1.	**UV-A Levels**					
(a)	N + Lo	-	210	90	30	20 * (208 cm)
		520	350	115	30	20 * (208 cm)
(b)	P + Lo	-	220	60	20	7 * (221 cm)
		600	360	80	20	8 * (221 cm)
(c)	M + Le	-	80	-	-	-
		210	90	-	-	-
2.	**UV-B&C Levels**					
(d)	N + Lo	-	0.125	0.05	0.025	0.01 * (208 cm)
		0.33	0.20	0.085	0.025	0.01 * (208 cm)
(e)	N + Lo	-	0.10	0.03	0.02	0.01 * (221 cm)
		-	0.37	0.06	0.02	0.01 * (221 cm)
(f)	M + Le	-	0.02	-	-	-
		0.40	0.18	-	-	-

Brian G. Phillips
Non-Ionizing Radiation Protection Officer
Radiation Health Branch

September 20, 1982

Attachement 1

Instrumentation Used for Measuring UV From Fluorescent Lighting

The instrumentation used for UV measurements at Wetaskiwin schools on 27 May and 15 September, 1982 were as follows:

1. UV-A: Blak-ray J221 longwave meter and
2. UV-B&C: International Light I.L. 530 Actinic radiometer

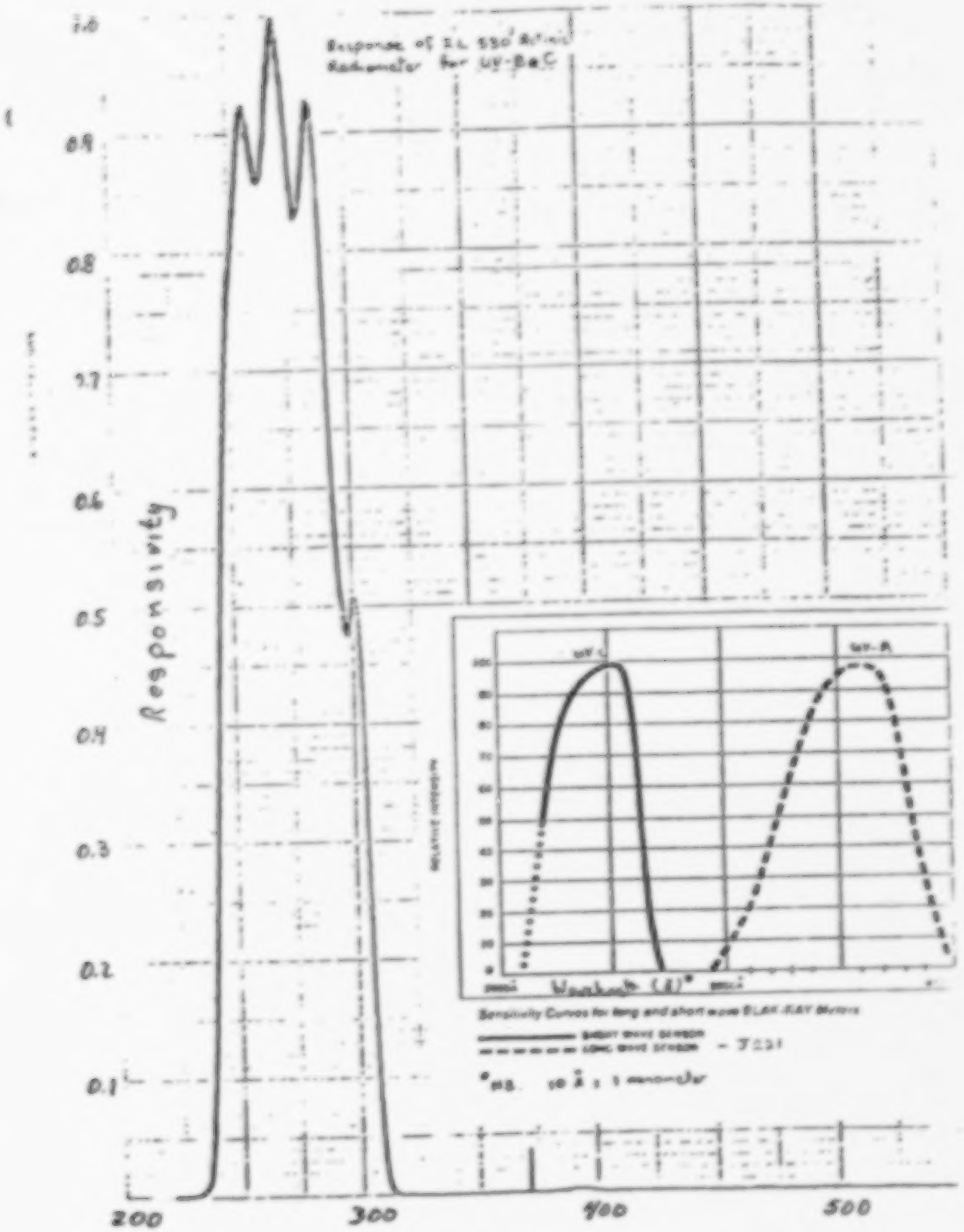
Note that each instrument has a spectral response (see attachment 2) which peaks at a specific spectral wavelength, with reduced sensitivity for wavelengths above and below this sensitivity peak. This means that the instrument does not respond equally at all wavelengths within its designated spectral range, the result being that the indicated levels are not absolute irradiance (power density) values. Only a calibrated spectroradiometer can give the absolute spectral distribution.

The I.L. 530 radiometer has its peak of sensitivity at 270 nm, to match the acute biological response of human tissue to UV-B&C exposure. The indicated levels in uW/cm^2 are strictly "effective" values weighted to the 270 nm equivalence of effectiveness.

The Blak-ray J221 is designed to respond to the 365 nanometer wavelength of emission from mercury vapour lamps. Fluorescent lights are a lower-pressure mercury vapour lamp. A spectroradiometric instrument response for the spectral emission of a typical cool white fluorescent lamp is given in attachment 3. This is the light output of a bare lamp before it is altered by troffer reflections and lens/louvre attenuation.

Brian G. Phillips
Non-Ionizing Radiation Protection Officer
Radiation Health Branch

September 20, 1982



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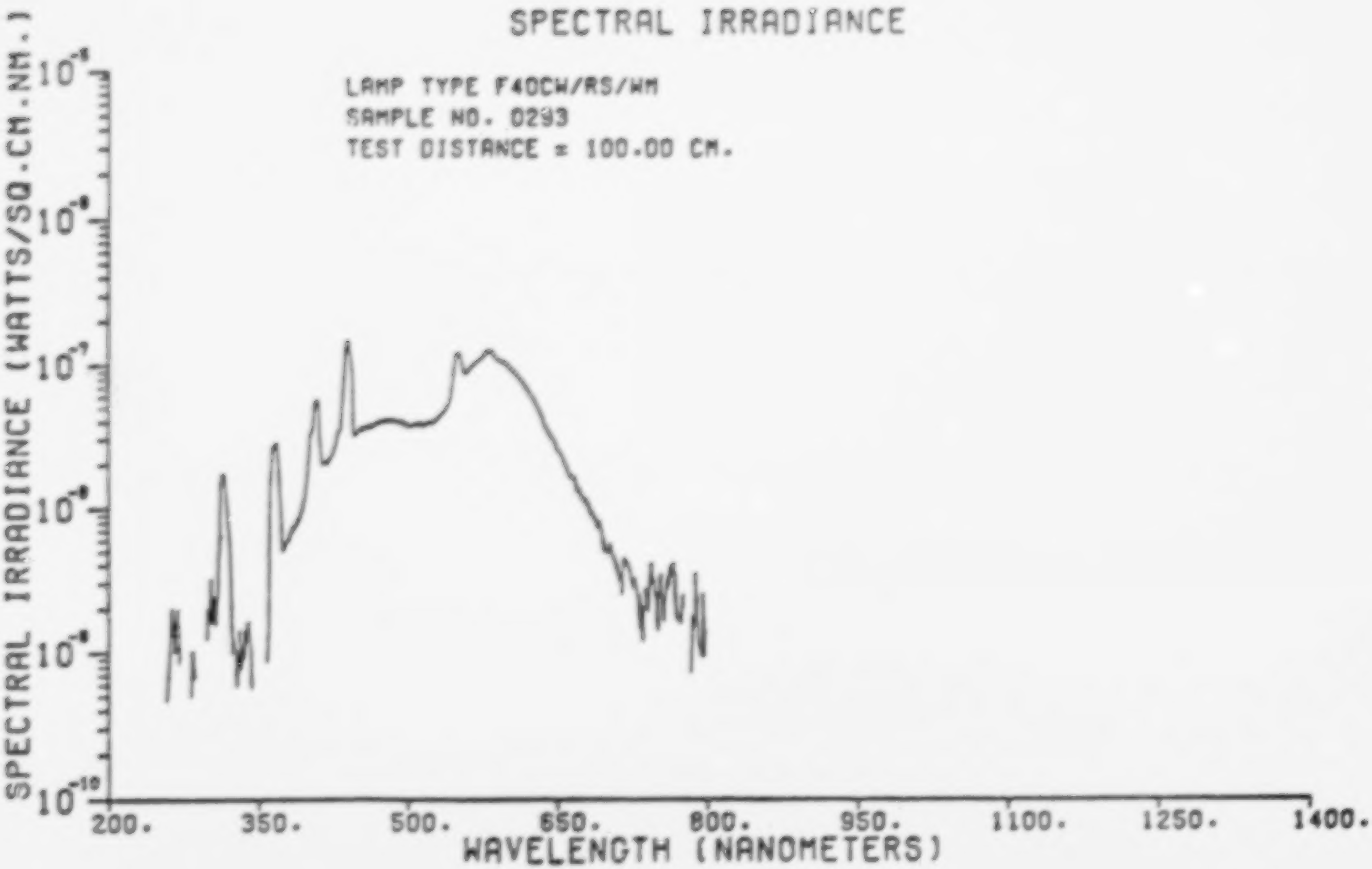
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1100.
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WAVELENGTH (NANOMETERS)

APPENDIX F

ILLUMINANCE SURVEY - SCHOOLS OF THE WETASKIWIN SCHOOL DISTRICT NO. 264

for

ALBERTA EDUCATION

1983-06-20

1. Introduction

This report summarizes the results of an illuminance survey in six classrooms of the Westaskiwin School District No. 264 (on 1983-04-06). A GEC "Minilux" photometer No. 6810 was used in the survey. The photometer had been calibrated in May 1982. A correction factor of 1.1 was applied to readings taken under Duro-Test Vita-Lite fluorescent lamps and a factor of 1.2 to readings under Cool White fluorescent lamps.

The results of the surveys are shown in Figs. 1-6 and compared in Table 1. Illuminances from the electric lighting systems were measured at a number of locations in each classroom and an average of the measurements calculated. As far as possible the measurements were taken remote from the windows in order to minimize the contribution of daylight to the measured illuminances.

Limitation of time prevented the adoption of the survey procedure outlined in the IES Lighting Handbook 1981 (Reference Volume) to obtain the average illuminance in each classroom.

2. Recommended Illuminances For General Purpose Classrooms

The illuminances recommended by the Illuminating Engineering Society of North America (IES), the Ontario Ministry of Education, and the (British) Department of Education and Science are given below.

2.1 Illuminating Engineering Society of North America (See "IES Lighting Handbook 1981: Application Volume")

The IES does not recommend a single illuminance for a classroom. Instead, it recommends illuminances according to the visual tasks to be undertaken and takes into account the age of the student, the importance of speed and/or accuracy in carrying out the tasks, and the reflectances of the tasks. It is impossible to apply these recommendations without knowing exactly what work is undertaken, what grade pencil or type of pen is used, and if the reading material is of good or bad contrast. Weighing these considerations as best possible, the resultant recommended illuminance will be in one of two categories:

200 lux or 500 lux

2.2 Ontario Ministry of Education (See "Lighting for Education": Ontario Ministry of Education 1981)

The recommended task illuminance for general purpose classrooms is 500 lux.

2.3 (British) Department of Education and Science (See "Guidelines for Environmental Design and Fuel Conservation in Educational Buildings: DES Design Note 17, 1979)

"Where fluorescent lighting is used the general level of illumination should not be less than 300 lux. . . . or 350 lux. . . . in schemes which rely on combined daylight and electric lighting."

3. Comments On Lighting In Individual Classrooms

3.1 Centennial School: Classroom 10 and ECS Classroom

It was claimed that Cool White fluorescent lamps were installed in these rooms although the colour of the lamps did not appear to be exactly that of the Cool White type. It was not possible to examine the lamps to clear up this point.

3.2 Norwood School: Room 8

This room looked somewhat dim. The following features contributed to this:

The louvres do not permit light from the lamps to escape from the luminaires at angles approaching the horizontal. Consequently, little light reached the walls to make them bright and, to a large extent, it is the brightness of the walls which determines how bright a room appears.

This was demonstrated by removing the louvre from one or two luminaires. The space then appeared brighter although very limited measurements showed that the illuminances on the desks was not increased. (This point needs to be checked by making a more detailed illuminance survey.) Removing the louvres exposed the lamps: they are too bright for use bare.

The average illuminance in the room was lower than that in the adjoining space and, more important, in that space considerable light reached the walls. These circumstances compounded the effect produced by the louvres as discussed above.

3.3 Norwood School: Room 8 and Parkdale School: Grade 5

Essentially, the same illuminance is produced in each room although each luminaire in the Parkdale school houses 2 - 4 ft. Vita-Lite lamps while each luminaire in the Norwood school houses three of these lamps. The illuminance in the latter school would consequently be expected to approach 50% more than that in the Parkdale school.

The apparently low efficiency of the Norwood school luminaires is probably due to the use of 1/2" aluminum louvres (whereas 3/4" aluminum louvres are used at Parkdale school). Also, the aluminum liner will contribute to the low efficiency although this contribution should not be major if the aluminum is ALZAK finished, as it is claimed to be. The visible light reflectance of this aluminum should be no more than ten percentage points less than that of white paint.

If the 1/2" aluminum louvre and liner could be replaced by a plastics lens and white paint respectively then the illuminances would increase since the latter combination of lens and paint is more efficient than the combination of louvre and liner (as will be noted from the illuminnances measured in Norwood School: #2 Room ECS). However, this replacement cannot be made since it is desired to get as much UV out from the luminaire as possible: the O'C-O' C-M report (June 3, 1982) shows that the plastics lens will transmit a much reduced amount of UVA and almost no UVB and UVC.

In sum:

It is recommended that a 3/4" aluminum louvre be tried in the Norwood school luminaires. Although this louvre is not particularly efficient, it should be more efficient than the 1/2" louvre.

It was found impossible to fit a 2" louvre in the Parkdale school luminaires. Might it be possible to suspend this louvre under and butting against the luminaire? And could this louvre be fitted in the same way to the Norwood school luminaires? It should work more efficiently than either the 1/2" or 3/4" louvres.

4. Uv Measurements Etc. (Phillips: January 12, 1983)

This report states that an illuminance of 21 fc was measured in the Norwood school at the test position with, it would appear, the photometer vertical. (The note "vert." has been made adjacent to the measurement.) Similarly, it appears that 12.5 fc were measured with the photometer horizontal.

It is requested that the above interpretation of the note "vert." (and also of the note "horizon.") be confirmed since the illuminance measured with the photometer horizontal and pointing towards the ceiling would be expected to be considerably greater than the illuminance measured with the photometer vertical.

The measurements taken at desk level and which are a subject of this report show an average illuminance of 35 fc in the Norwood school: Room 8 and an illuminance of 31 fc at a point similar to the test position adopted in the Phillips report.

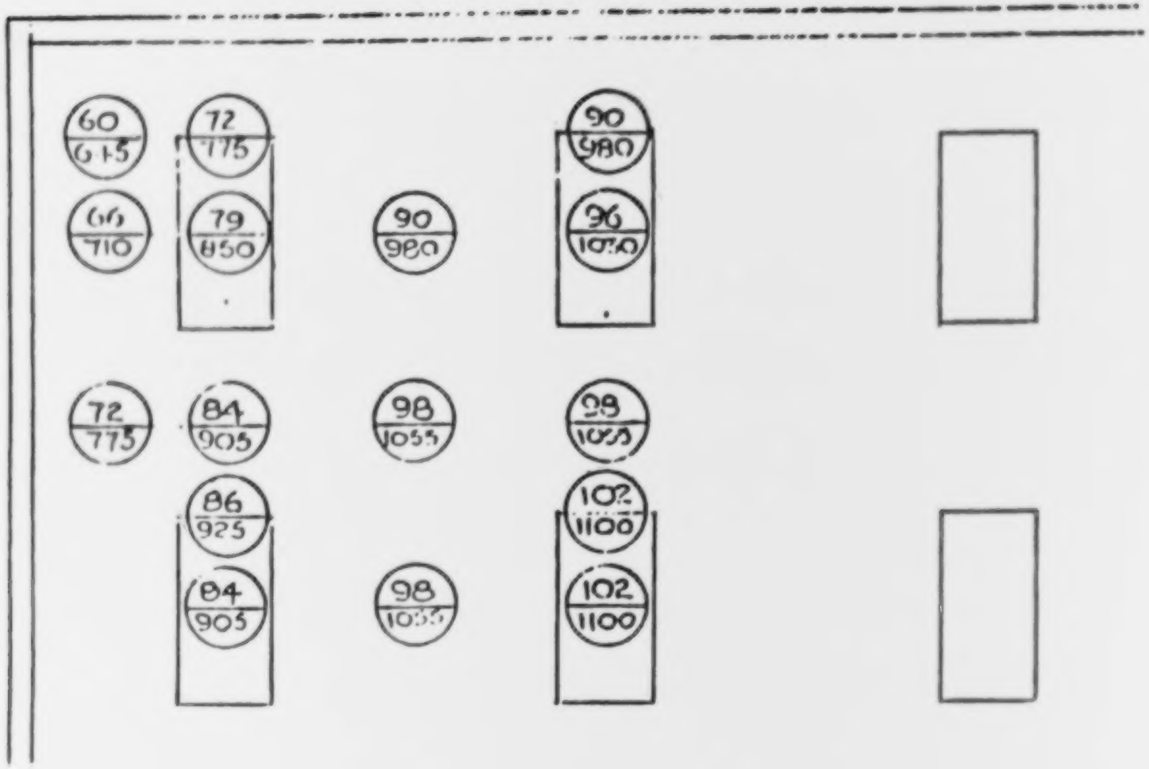
There is no obvious explanation for the difference between the above measurements and the single measurement by Phillips.

Incidently, the sketch in the Phillips report indicating the test position shows a square luminaire whereas a 2 x 4 luminaire is installed in Norwood School: Room 8. Were the measurements covered by the Phillips report and the present report both taken in the same room?

TABLE I

School	Luminaire	Lamps	Lens or Louvre	Luminaire Spacing ft.	Averaged Illuminance fc	Averaged Illuminance lux
Centennial: ECS Room	2 x 4 Recessed	4-4 ft CW(1)	Plastics Lens	8 x 8	85	920
Centennial: Room 10	1 1/2 x 4 Surface	4-4 ft. CW(1)	Plastics Wrap	8 x 8	104	1120
Norwood: #2 Room ECS	2 x 4 Recessed	3-4 ft. 40W V-L	Plastics Lens	8 x 8	57	610
Norwood: Room 8	2 x 4 Recessed	3-4 ft. 40W V-L	1/2" AL Louvre (& AL liner)	8 x 8	35	380
Parkdale: Grade 5	1 x 4 Surface	2-4 ft. 40W V-L	3/4" AL louvre	8 x 4	33	360
Parkdale: Open area	1 x 4 Surface	2-4 ft. 34W V-L	Plastics Wrap	8 x 4	66	710

Note: (1) Unable to confirm that the lamps are Cool White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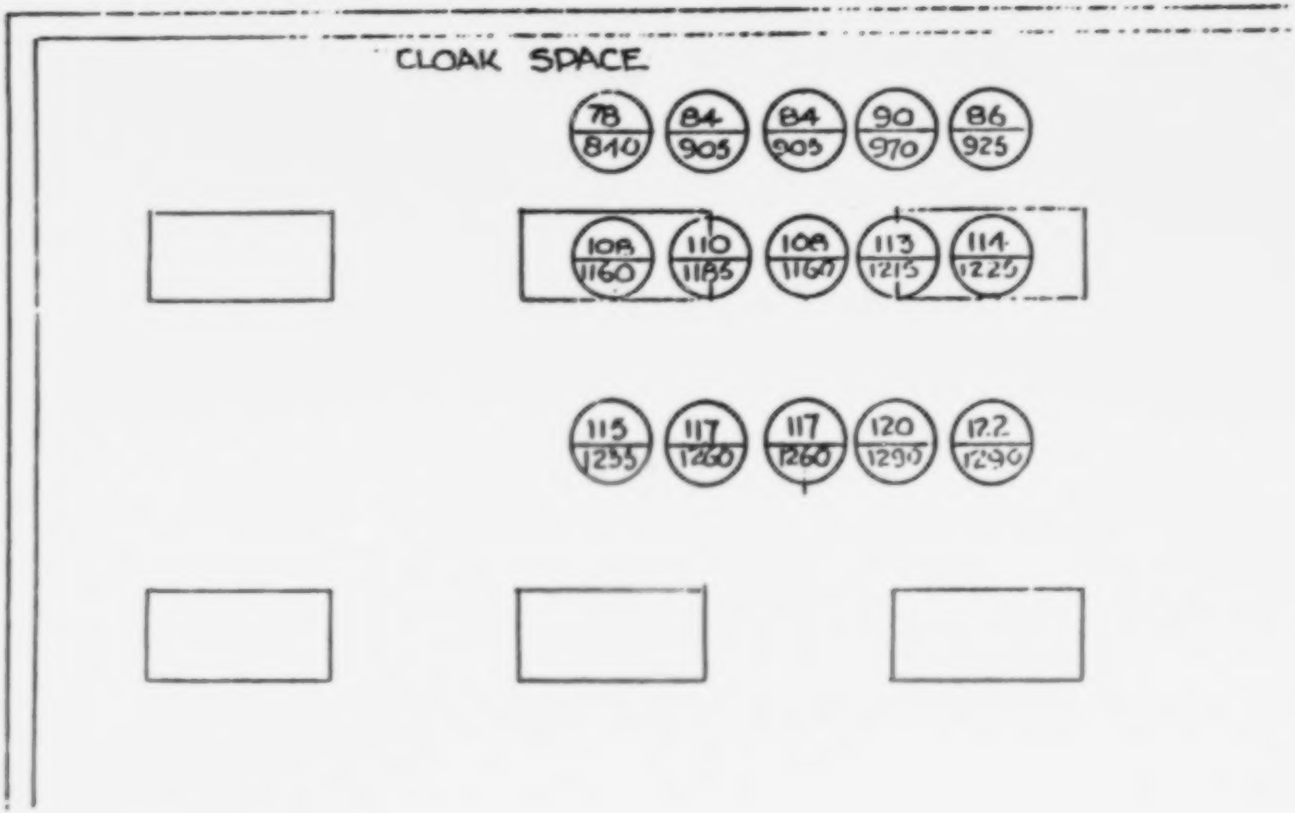
Centennial School, Wetaskiwin: ECS Classroom
Illuminance Survey

Figure 1

Luminaire: 2 x 4 recessed with lens and 4 - 4 ft. Cool White (?) lamps
Date of survey: 1983-04-06 (11:15 am)
Type of day: Bright and sunny
Window shading: Blinds in UP position
Plane of illuminance measurements: Horizontal at 22" above floor
Room decoration: Walls - beige
Carpet - beige
Scale: 1/4" to 1 ft.

XX footcandles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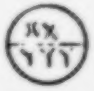
122
1290

Centennial School, Wetaskiwin: Classroom 10
Illuminance Survey

Figure 2

Luminaire: Surface mounted with wrap-around lens and 4-4ft. Cool White (?) lamps
Date of survey: 1983-04-06 (noon)
Type of day: Bright and sunny **Window shading:** Blinds in DOWN position
Plane of illuminance measurements: Horizontal at 26" above floor **Scale:** 1/4" to 1 ft.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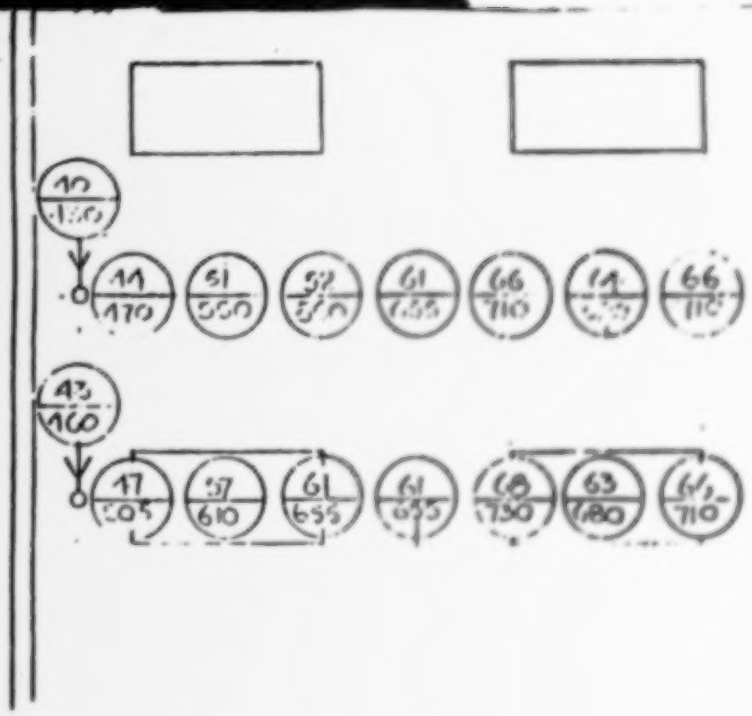
lux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710

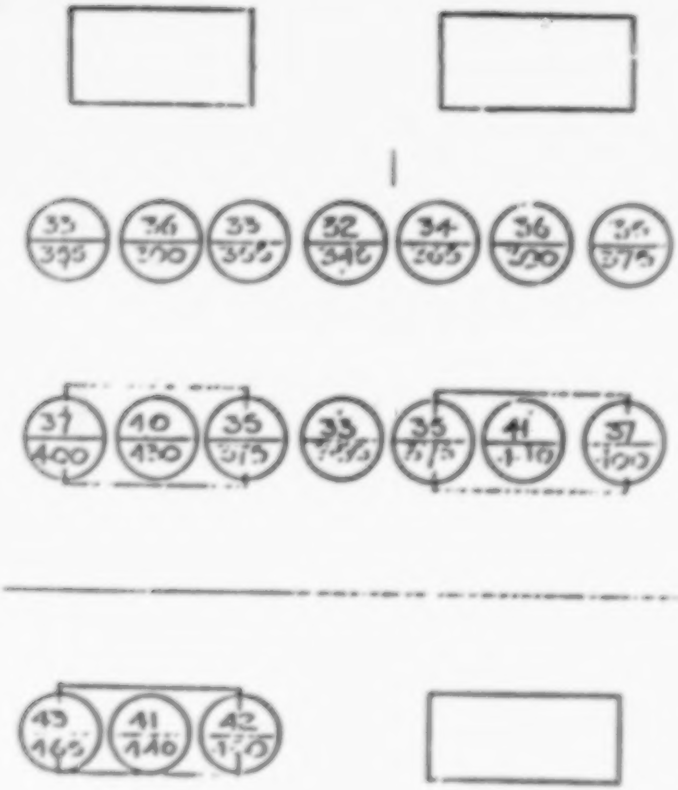
Norwood School, WEtaskiwin: #2 Room ECS
Illuminance Survey

Figure 3

Luminaire: 2 x 4 recessed with lens and 3 - 4 ft. 40W
Vita-Lite lamps
Date of survey: 1983-04-06
Plane of illuminance measurements: Horizontal at desk top
Scale: 1/4" to 1 ft.

footcandles

lux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465
41
440
42

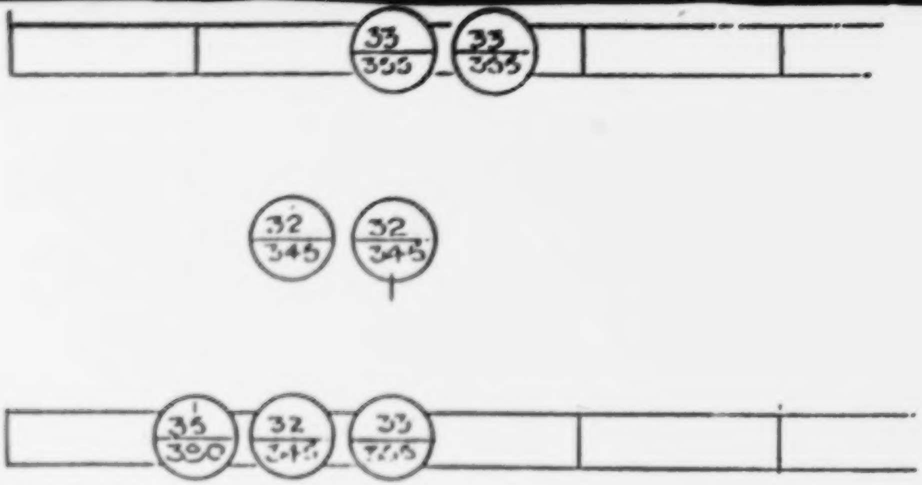
ILLUMINANCE UNDER ONE LUMINAIRE WITH LOUVRE REMOVED

Norwood School, Wetaskiwin: Room 8
Illuminance survey

Figure 4

Luminaire: 2 x 4 recessed with 1/2" x 1/2" Anodized aluminum louvre and liner, and 3 - 4 ft. 40W Vita-Lite lamps
Date of survey: 1983-04-06
Plane of illuminance measurements: Horizontal at desk top
Scale: 1/4" to 1 ft.

xx footcandles
yyy lux


33
355
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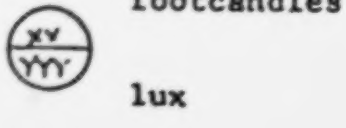
355
32
345
32
345
35
380
32
345
33
355

Parkdale School, Wetaskiwin: Grade 5
Illuminance Survey

Figure 5

Luminaire: 1 x 4 surface mounted with 3/4" x 3/4" Anodized
aluminum louvre and 2-4 ft. 40W Vita-Lite lamps
Date of survey: 1983-04-06
Plane of illuminance measurements: Horizontal at desk top
Scale: 1/4" to 1 ft.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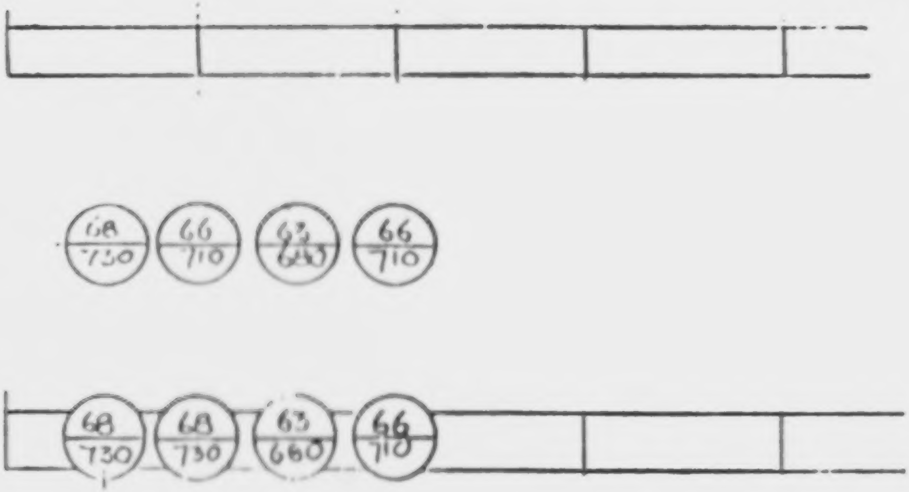
68
730
66
710
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683
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710
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730
68
730
63
660
66
710

Parkdale School, Wetaskiwin: Open area adjacent to UV room
Illuminance survey

Figure 6

Luminaire: 1 x 4 surface mounted with wrap-around lens and
2-4 ft. 34W Vita-Lite lamps
Date of survey: 1983-04-06
Plane of illuminance measurements: Horizontal at desk top
Scale: 1/4" to 1 ft.

footcandles

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